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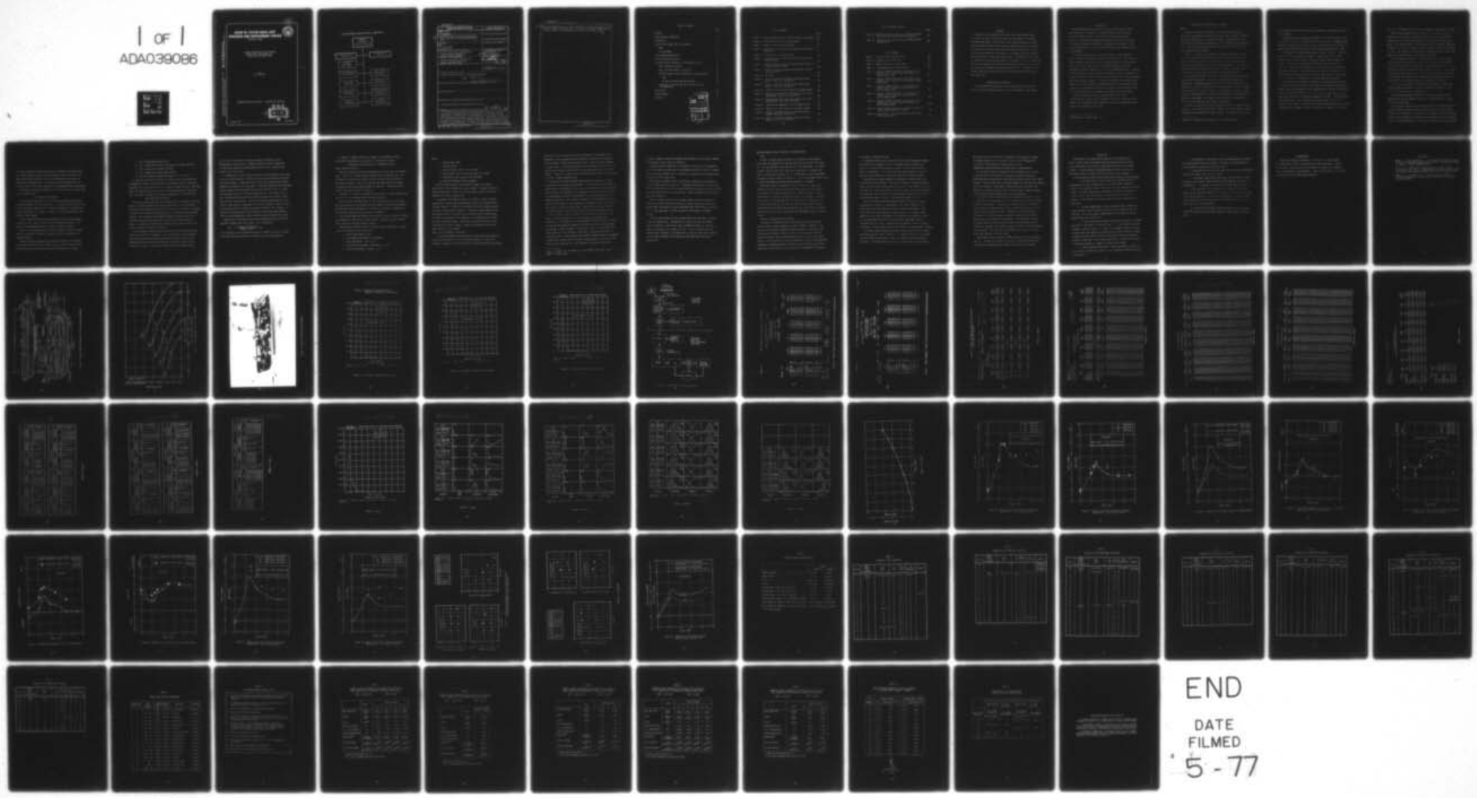

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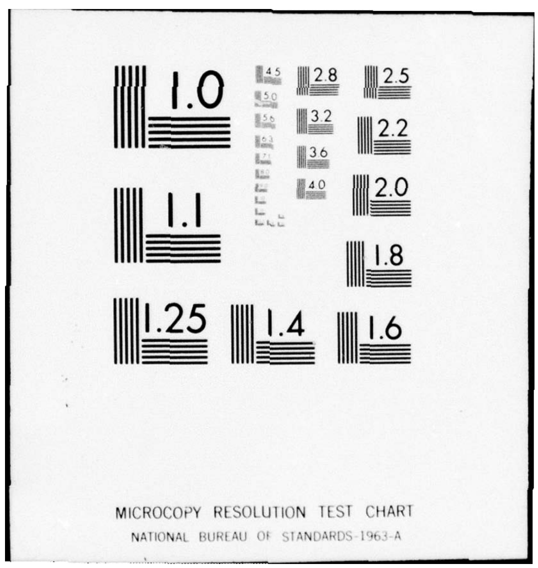
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Bethesda, Md. 20084

MOTIONS AND DRAG OF AN AIR CUSHION VEHICLE WITH A DEEP SKIRT IN CALM WATER AND RANDOM WAVES

by

Alvin Gersten

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January 1977

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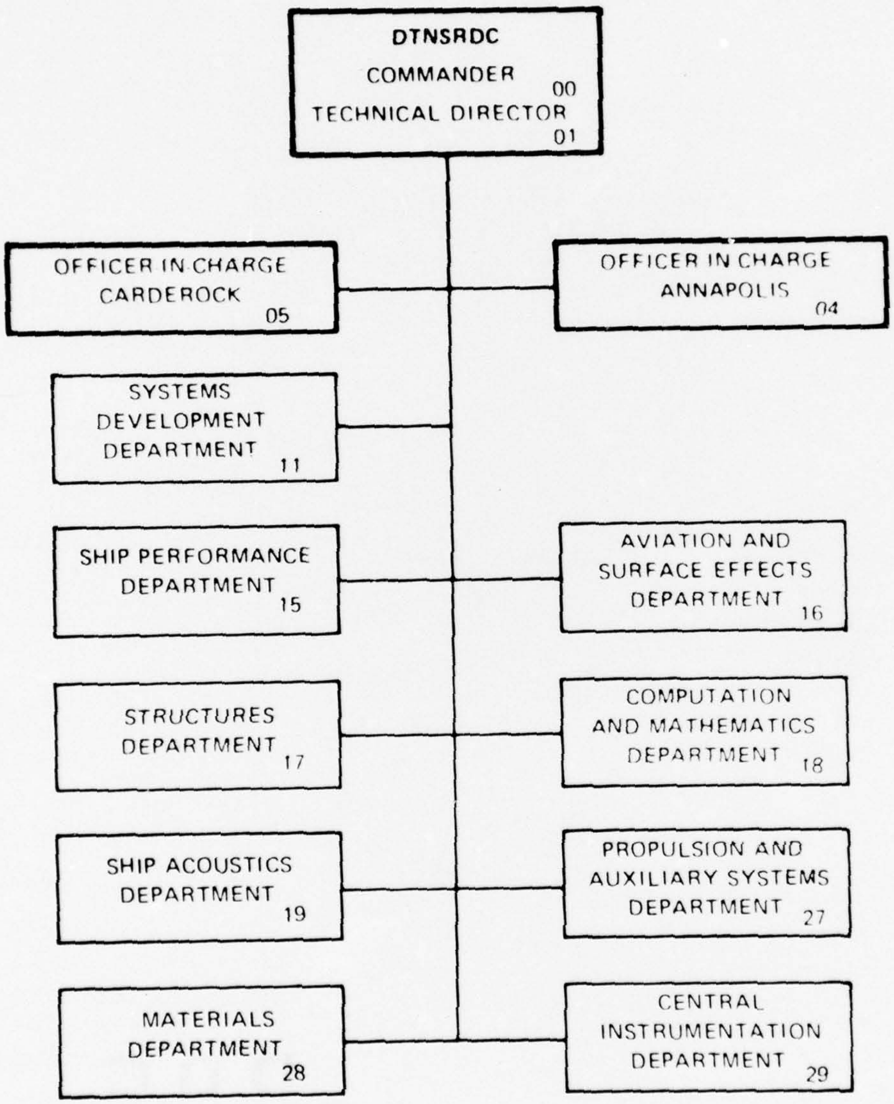

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A model of an air cushion vehicle (ACV) with a deep pericell-type skirt and high cushion loading has undergone experiments in calm water and head random waves. The main goal of the investigation was to obtain drag and motion data which can be used to guide the design of a prototype. The results will also be used to validate computer predictions. Plots of mean drag are presented in this report, as are tables containing standard deviation values of motions and accelerations. The effect of model weight and volume air flow on drag and motions is discussed. It is also shown that this heavily loaded

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cont ACV has higher hump and post-hump drag than a similiarly configured ACV with smaller payload and shorter skirt. In addition, the heavier, deep-skirted vehicle pitches less and heaves about the same as the other craft.

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ABSTRACT

A model of an air cushion vehicle (ACV) with a deep pericell-type skirt and high cushion loading has undergone experiments in calm water and head random waves. The main goal of the investigation was to obtain drag and motion data which can be used to guide the design of a prototype. The results will also be used to validate computer predictions. Plots of mean drag are presented in this report, as are tables containing standard deviation values of motions and accelerations. The effect of model weight and volume air flow on drag and motions is discussed. It is also shown that this heavily loaded ACV has higher hump and post-hump drag than a similiarly configured ACV with smaller payload and shorter skirt. In addition, the heavier, deep-skirted vehicle pitches less and heaves about the same as the other craft.

ADMINISTRATIVE INFORMATION

The investigation dicussed herein was funded by the Advanced Naval Vehicles Concepts Evaluation Program, Task Area S0407056, Element 63564N.

INTRODUCTION

Model experiments were carried out on an air cushion vehicle (ACV) with a deep skirt in support of the Advanced Naval Vehicles Concepts Evaluation (ANVCE) Program. The purpose of these experiments was primarily to determine the seakeeping characteristics of the craft when it is heavily loaded and underway at high speed in random waves. Scale ratios were selected so that 1,000 and 3,000 metric ton prototypes could be represented.

The ANVCE Program was set up within the Chief of Naval Operations Office to evaluate nine generic concepts including ACV's[1*]: the military worth, technical feasibiliy and cost of these concepts is to be evaluated. After carrying out state-of-the-art assessments, analyses and model experiments are being conducted to fill in the technological gaps. Attention is being directed in ANVCE to determining whether military value exists for larger, faster ACV's, where the drag reducing features are of more importance than the amphibious features. It has been determined that because surface effect ships (SES) sidehulls have prohibitive drag at Froude numbers above roughly 2.0 (corresponding to 80 kts for a 2,000 to 3,000 ton vehicle) the ACV is more efficient (i.e. consumes less power) at such high speeds.

The ACV "Advocate Office" of the ANVCE Program had a model constructed, and in August 1976, requested the David W. Taylor Naval Ship Research and Development Center (DTNSRDC) to conduct the experiments whose results are presented in this report.

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*References are listed on page 19.

DESCRIPTION OF MODEL AND TEST EQUIPMENT

MODEL

The basic hull form of the model is essentially the same as the JEFF (A) of the Amphibious Assault Landing Craft (AALC) Program. However, the skirt--although also of the pericell type--is much deeper than the AALC design (cell height/hull beam equal to 0.20 compared to approximately 0.11). The model skirt was fabricated from 0.005 in. (0.013 cm) thick nylon coated with polyurethane.

Figure 1 is a sketch of the model and indicates the location of the ten fans that were available for pressurizing the cushion and skirt loop: four fans fed the cushion and six fed the loop. As will be seen later, various fan combinations were used during the experiments. The fans were Aximax 3 type with a maximum rpm of 22,500. Figure 2 gives the volume flow rate for a single fan as a function of back pressure and rpm.

As can be seen in Table 1 which lists the model particulars, two model weights were investigated. As a result, two cushion pressures were established: a measured average value of 10.7 psf (512.3 Newtons/m^2) was obtained for the 188.2 lb (85.4 kg) gross weight, and 7.5 psf (359.1 Newtons/m^2) for the 125.5 lb (56.9 kg) weight. This resulted in a cushion loading ($p_c/\sqrt{s}$)* of 400 Newtons/m^3 for the heavy displacement and 285 Newtons/m^3 for the light displacement. The loop-to-cushion pressure ratio was about 1.1 and 1.3 for the heavy and light weights, respectively.

The hull was mainly made from polyurethane foam with a fiberglass outer covering. Four aluminum longitudinal stringers and several mahogany plywood bulkheads were incorporated for added strength. The gimbal used to allow

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* Where p_c is the cushion pressure and S is the cushion area.

pitch freedom was installed with its pivot located at the weather deck level.

TEST EQUIPMENT

The experiments were conducted at DTNSRDC in the 1,400 ft (426.7 m) long tank, which is 22 ft (6.7 m) deep and 51 ft (15.5 m) wide. A pneumatic-type wavemaker located at one end of the tank can be electronically controlled to generate long-crested random waves having a pre-programmed spectral shape.

A photograph of the experimental setup is shown in Figure 3. Since the model was not self-propelled or steered, it was necessary to provide an external force to move the model forward at constant speed and keep it on course. This force was supplied by the towing gear partially shown in Figure 3. Freedom in pitch, heave and roll was allowed, and yaw, sway and surge were restrained. The towing gear--which was mounted forward of the main carriage to enable the model to travel through relatively undisturbed air--also served as a reference for the motion measuring transducers.

High resolution potentiometers mounted on the towing gear were utilized for measuring the craft motions. Systron-Donner force-balance servo-accelerometers were used to measure vertical accelerations at the bow, CG and stern; these gages had rated ranges of $\pm$ 5G, $\pm$ 2G and $\pm$ 2G, respectively. Figure 1 shows the location of all transducers mounted on the model. Impact pressure was measured with a flush mounted pressure gage located 3.8 ft (1.2 m) forward of the transom. This Kulite solid-state pressure sensor has a silicon diaphragm with a diameter of 0.152 in. (0.386 cm), a range of 0 to 10 psig,

(0 to 6.9 x 10^4 Newtons/m^2) and a natural frequency of approximately 70 kHz.

Endevco pressure gages having a range of 0 to 0.7 psi (0 to 4.8 x 10^3 Newtons/m^2) were employed for measuring bubble and skirt loop pressures. These gages are of the diaphragm-type, and contain semi-conductor strain gages as the sensing element. The reference side of the pressure gages was connected to a region of constant pressure which was protected from ambient air flow. Short pieces of flexible tubing connected the active side of the gages to piezometer openings in the bottom of the model.

Drag was measured by means of a "block gage", which is a cube-shaped module containing flexures and a differential reluctance sensing element. The gage was installed in the heave staff directly above the gimbal. For the early calm water experiments a block gage with a ±25 lb (11.3 kg) rated range was employed; after Run 6, a 100 lb (45.4 kg) gage was substituted. A strain-gaged ring gage was used to monitor model weight periodically to insure that it had not been altered due to absorption of moisture.

An ultrasonic transducer was used for the measurement of wave height. The wave probe was located 2.7 ft (0.8 m) forward of the model's CG and 10.9 ft (3.3 m) to port of its centerline.

Since the model speed was identical to the carriage speed, it was determined by use of a magnetic pickup and a slotted wheel which rotated with the carriage wheels.

The transducer signals were amplified and then directed through one of several available recording schemes depending on their frequency content. Signals which fluctuated at a relatively low frequency (e.g. pitch and heave motions at the frequency of wave encounter) were digitized using a sampling rate of 50 samples/channel/sec. Digitization was done in real time and post-

run data processing of wave inputs and vehicle responses was then carried out. Impact pressures, which are high frequency (short rise time) transducer outputs were recorded on string oscillograph type strip chart for later direct reading by hand. This device has a flat response into the kHz range, which is more than adequate for the phenomenon being investigated.

Video tape recordings were made of all runs, and 16 mm color movies were taken of selected runs.

TEST PROGRAM AND PROCEDURE

The experiments were carried out in calm water and head random waves. A detailed summary of the test conditions is provided in Table 2 where it can be seen that model speeds up to 18 kts were investigated in calm water and scaled random waves up to State 4 in severity. Some runs were made in Sea State 6 at lower speeds.

The fans operating during the experiments and their rpm were changed frequently to vary cushion loading, volume flow and daylight gap. The numerical fan designations given in Table 2 are keyed to Figure 1.

Table 3 is a condensed version of Table 2 without indication of model speed, but containing "condition" numbers which will be referred to in subsequent graphs.

Samples of spectra representing the energy distribution of the waves in the towing tank are given in Figures 4a to 4c. Typical values of the wave statistics are given on each figure with definitions as follows:

a. AVE = average peak-to-peak value

b. SIG = "significant" value or average of the highest one-third

c. APP = average of the highest one-tenth

d. RTE = square root of area under spectrum

e. RQO = $\sqrt{2}$ times the standard deviation σ, (i.e. root Q_o)

It should be noted that the spectra in Figures 4a and 4b represent the designated sea states for a scale rate of 22.7 whereas Figure 4c represents Sea State 6 for a scale ratio of 37.5. During the random wave runs, sufficient passes were made down the tank to have the model encounter about 150 waves; this size sample is assumed to be a good representation of the population.

DATA REDUCTION AND ANALYSIS

The digital system consisted of an Interdata Model 70 computer with 64 KB memory, a nine-track Kennedy 3110 digital tape drive, an ASR-33 teletype, an Analogic 5800 analogue to digital (A to D) and D to A converter, a Versatec 1100A Matrix 600 line-per-minute printer, and a Tridata 1024 cartridge tape recorder. While sampling, data summations used at the end of each run to calculate mean and standard deviation for each channel were retained in memory. In addition, all data were calibrated in volts and written on the digital tape (see flow chart in Figure 5).

A minimum analysis (mean, standard deviation and root Q_o) was performed after each run for all 11 channels. This was done twice on each computer printout--once after passing the analogue signal through 10 Hz, 6 pole, Butterworth filters, and a second time after passing the signal through similar 6 Hz filters. A 6 Hz filter tends to provide a cleaner signal,

and a 10 Hz filter would allow higher frequency information to pass unattenuated, if such exists. Subsequent spectral analysis showed that no significant energy was present beyond about 5Hz, thus indicating the suitability of 6Hz filters.

In random waves, a zero-crossing routine was used to determine the number of cycles of wave encounter. Maximum, minimum and average double amplitudes were also evaluated. Random wave runs for the same condition were grouped together and treated as one long sample. After the experiments were completed, spectral analysis and time-domain analysis were carried out for all random wave groupings and for all channels except velocity. The DTNSRDC Control Data Corporation 6700 computer and Stromberg Carlson 4060 (SC4060) plotter were used for these analyses. Spectra and histograms were generated by the DTNSRDC "Power Spectra, Histograms, and Fourier Transforms" (PSHAFT) program in conjunction with the "General Printing and Plotting" (GPP) program. In addition to plotting spectra and histograms, response amplitude operators (RAO's) and non-dimensional transfer functions were plotted by the SC 4060.

Resolution for the spectral analyses was selected so that at least 40 degrees-of-freedom (DOF) would result. DOF is defined by

$$\text{DOF} = \frac{2 \cdot \text{number of data points}}{\text{number of lags}} + 0.5$$

The calculation of auto-correlation function in PSHAFT allows for a maximum of 60 lags (these are analagous to frequencies in the FFT procedure).

A summary of comments relative to changes in instrumentation setup and problems encountered during some runs is contained in Table 4.

PRESENTATION AND DISCUSSION OF EXPERIMENTAL RESULTS

SAMPLE COMPUTER PRINTOUTS

Real-time computer analysis was performed for all runs made in the towing tank. Figure 6 is a sample printout obtained from a random wave run. The calm water run analysis was similar to that in Figure 6, but omitted the reference to heading. Several runs made for the same conditions to obtain an adequate sample were grouped together for analysis. Typical results for runs 23, 24 and 25 are given in Figure 7.

The mean ("d.c. level"), standard deviation or RMS (σ) about the mean, and root Qo ($\sqrt{2}\sigma$) for the measurements made are tabulated.

After finishing the experiments, a more thorough analysis of the random wave runs was done in the frequency and time domains on the CDC 6700 computer, and computer plots were prepared. An example of the output is presented in Figure 8 which does not show results for all channels.

The 5 percent amplitude ranges given on sheets c and d of Figure 8 indicate the bandwidth for which the individual spectral ordinates do not get smaller than 5 percent of the peak spectral ordinate.

Nondimensional transfer functions listed on sheet d and plotted on sheets j and k are defined in the following way:

a. angular measurement: angle/θ

b. displacement measurement: displacement/r

c. force measurement: force $\cdot L_c/r\Delta$

d. acceleration measurement: acceleration $\cdot G/\omega_e^2 r$

e. pressure measurement: pressure $\cdot L_c^3/r\Delta$

where:

θ = maximum wave slope

r = wave amplitude

L_c = cushion length (5.98 ft (1.82 m) used)

Δ = model weight (188.2 lb (85.4 kg) used in all cases)

G = acceleration due to gravity (32.2 ft/sec^2)

ω_e = measured frequency of wave encounter

The time domain analysis results begin on sheet e of Figure 8. Tabulations of the histograms are shown on sheets f through h where the heading "Data Points" refers to individual points on the time-history, separated in time by 1/sample rate.

The computer plots begin on sheet i of Figure 8. Sheet j contains auto-spectra, response amplitude operations (RAO's) and nondimensional transfer functions. The RAO's are obtained by dividing response spectral ordinates by wave spectral ordinates. Statistical values obtained from the spectral analysis are shown on the left-hand side of these figures. The statistic labeled as "APP" (apparent) is the average of the highest one-tenth double amplitudes. Statistical values are also given on the histograms which start on sheet l; these are derived from direct time domain analysis of the signals.

DRAG, TRIM AND SINKAGE IN CALM WATER

Air tares were measured with the model raised so that the bottom of its skirt would be about 6 in. (15.2 cm) above the water if it were fully extended. Because of this large daylight gap the cushion and loop pressures

were quite low, and the skirt was easily deflected by impingement of air. Therefore, a thin, plywood sheet was attached to the bow hard structure so that the model's frontal area was always equal to that for normal operation in ground effect. Six fans were operating as indicated for runs 72 to 91 in Table 2, and the total volume flow of air was approximately 15.4 cfs (0.44 m^3/sec). Figure 9 is a plot of the air tare drag which reaches 6 lbs (2.7 kg) at 18 kts (including momentum drag).

Drag results from the calm water experiments are presented in Figures 10 through 12 for two model gross weights. To arrive at the values given in these figures, fan momentum drag for the air tare experiments was substracted from Figure 9*; the resultant (i.e. aerodynamic form and friction drag) was then substracted from total drag measured with the model operating at its normal daylight gap. Thus, Figures 10 through 12, and subsequent drag plots, contain only hydrodynamic drag components and momentum drag for the particular fan condition specified in each figure. Negative drag values are found at zero speed because air exiting from the pericells produced forward thrust.

Each of Figures 10 and 11 contains data for several fan conditions (see Table 3 for specifications) and a curve has been faired through one condition run. In Figure 10, for a model weight of 188.2 lb (85.4 kg) it can be seen that drag does not change with fan condition until post-hump speeds are reached; it then increases for conditions 2 and 3 -- both of which have lower volume air flow. Naturally, less power is absorbed by the fans in conditions 2 and 3, thus indicating the trade-off between effective horsepower (proportional to drag) and fan horsepower (proportional to volume air flow). Figure 13 shows that the trim was essentially the same for conditions

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*$D_{mom} = \rho QV$ where ρ is air density, Q is the volume flow, and V is the model's' forward speed.

1,2 and 3; however, Figure 14 indicates that the model ran more deeply immersed for conditions 2 and 3 than for condition 1.

The data point for condition 15 in Figures 10, 13 and 14 is an example of results from some runs made late in the program during which the skirt assumed an unusual shape--probably due to a reduction in cushion pressure brought about by parting of skirt glue joints.

Model drag at a weight of 125.5 lb (56.9 kg) is generally not affected by the fan changes made (see Figure 11). Although during Condition 7 several more fans were operating than during the other conditions, and with at least as high an rpm, the faired curve is, for the most part, closely followed by the cluster of data points around it.

Figure 12 compares drag for the two model weights with some influence of varied fan condition also coming into play. Drag is greater for the larger gross weight, particularly at hump speed where the curves differ by a factor of 1.7. The hump speed is almost the same for both weights, averaging 5.5 kts.

Trim and static heave for the two model weights are compared in Figures 15 and 16, respectively. Although the air flow is less for the lighter craft, the weight is sufficiently lower to enable the model to ride less deeply in the water up to a speed of 10 kts. Trim is more bow up at the lighter weight--maximum 2.3 deg compared to 1.5 deg--at least partly because the less deeply immersed skirt experiences less drag (ergo smaller bow down moment).

DRAG AND DYNAMIC VEHICLE RESPONSES IN IRREGULAR WAVES

Drag

Figure 17 contains mean drag results for operation in Sea States 3 and 4; they are compared with the calm water drag curve taken from Figure 10. The fan condition is the same for all of the data shown. At a model weight of 188.2 lb (85.4 kg), hump drag in Sea State 3 is greater than that in calm water by a factor of 1.1. In Sea State 4, hump drag exceeds calm water drag by a factor of roughly 1.2. At cruising speeds there is also a significant added drag penalty during operation in a seaway.

When model weight is decreased to 125.5 lb (56.9 kg), there is no apparent increase in drag at hump speed during operation in Sea State 4 as compared to calm water (see Figure 18). Further increase in speed does result in a substantial added drag penalty in the seaway. Hump drag in Sea State 6 is greater than the calm water value by a factor of 1.2. It should be pointed out that more fans were used during the calm water experiments than during the wave experiments; this would tend to increase momentum drag in calm water and decrease the hydrodynamic drag at cruising speeds.

Motions, Accelerations and Pressures

A summary of standard deviation (root-mean-square about the mean) values of model dynamic responses is given in Tables 5 through 9. Two scale ratios were used in determining wave dimensions in the towing tank: for the data in Tables 5, 6 and 7 a value of 1:22.7 was used; for the results in Tables 8 and 9, the appropriate value is 1:37.5. For a scale ratio of 1:22.7, the 188.2 lb (85.4 kg) model with a $p_c/\sqrt{S}$ of 400 Newtons/m^3 represents a prototype weighing 1,000 metric tons; the 125.5 lb (56.9 kg) model with a scale ratio of 1:37.5 and $p_c/\sqrt{S}$ of 285 Newtons/m^3 represents

a prototype of 3,000 metric tons.

By comparing Tables 5 and 6, one can see how vehicle responses increase with sea state at a speed of 6 kts. For example, heave increases by a factor of 2.2 and pitch increases by a factor of 2.4 in going from Sea State 3 to Sea State 4. It is also clear that the fluctuation in cushion and skirt (loop) pressure is significant relative to the mean pressure.

Accelerations are severe enough at high speeds to indicate that crew discomfort could be a problem. Particularly noteworthy are bow acceleration levels of 0.45 G's and CG accelerations of 0.23 G's in Sea State 6 at 10 kts (see Table 9). Even in Sea State 4, as Table 7 shows, the standard deviation of acceleration can be large, with bow acceleration reaching 0.40 G's and CG acceleration equal to 0.26 G's when the model speed is 14 kts.

Plots of the motion and acceleration results as a function of speed are provided in Figure 19. Heave appears to be almost insensitive to speed changes over the rather broad range in speeds investigated. Pitch, on the other hand, does decrease as speed increases. For example, when operating at the light displacement in Sea State 4, the standard deviation of pitch decreases from 0.54 to 0.28 (48 percent) when model speed is increased from 6 to 18 kts. Accelerations are generally found to increase with speed, to a large extent because the frequency of wave encounter increases.

The largest impact pressures measured on the wet deck during the random wave experiments are given in Table 10. Run numbers are given in this table so that reference can be made to Table 2 for determining the experimental conditions. The sketch below the listing of values shows that the readings

were made from the initial point of departure of the pulse to its peak. The largest impact for all runs was 1.57 psi (1.08×10^4 Newtons/m^2): it occurred in Sea State 4 at a model speed of 14 kts.

COMPARISON OF DRAG AND MOTIONS FOR ANVCE AND AALC CONFIGURATIONS

An ACV model having hull proportions and configuration very similar to the one used for the present investigation underwent towing tank experiments under sponsorship of the Amphibious Assault Landing Craft (AALC) program.[2] There are two major differences between the AALC and ANVCE designs: first, as discussed in this report's section describing the model, the ANVCE skirt is twice as deep as that on the AALC model; second, the ANVCE vehicle was more heavily loaded than its AALC counterpart.

Calm water drag for these two designs is compared in Figure 20. This is total drag (i.e. aerodynamic drag is included) since only total drag was available in Reference 2. Hump drag for the ANVCE model is 1.4 times as high as that for the AALC vehicle; this is probably due primarily to the heavier loading of the ANVCE craft. Reference 3 shows that the wave resistance of a uniform pressure distribution moving over calm water is proportional to the square of its magnitude. At higher speeds, as wave resistance decreases, the total drag of both vehicles decreases before starting to rise again with further increase of friction. form and momentum drag components. At 15 kts drag of the ANVCE craft is still 1.5 times larger than the drag of the AALC model.

Some comparisions of motions for ANVCE and AALC ACV's are provided in Table 11. The deep skirt appears to result in significantly lower unit pitch response; however, heave is about the same for the two models.

CONCLUSIONS

An ACV model with a deep pericell-type skirt was tested at the David W. Taylor Naval Ship Research and Development Center to provide a data base which can be used for evaluating the merits of this design concept. The model speeds investigated ranged from zero to very high equivalent values for scaled 1,000 to 3,000 metric ton prototypes.

The following conclusions can be drawn from the results of this program:

1. At a model weight of 188.2 lb (85.4 kg) calm water drag (i.e. hydrodynamic drag plus momentum drag) is not significantly affected by changes in fan condition (number of fans and rpm) until post-hump speeds are reached. At these higher speeds, drag tends to increase with decrease in volume air flow. When model weight is reduced to 125.5 lb (56.9 kg), changes in fan conditions do not affect drag significantly throughout the speed range.

2. At model speeds above 1.5 kts, calm water drag is greater for a model weight of 188.2 lb (85.4 kg) than it is for a weight of 125.5 lb (56.9 kg). At the hump speed of approximately 5.7 kts drag for the two weights differs by a factor of 1.7.

3. For the heavier gross weight, hump drag in Sea State 3 is greater than that in calm water by a factor of only 1.1. In Sea State 4 the factor increases slightly to about 1.2. There is no increase in hump drag at the lighter weight when comparing calm water and Sea State 4 operation; however, increasing the wave severity further to Sea State 6 causes a 20 percent increase in hump drag. At cruising speeds there is a significant increase in drag when underway in a seaway as compared to calm water.

4. When encountering Sea State 4, heave increases by a factor of 2.2 and pitch increases by a factor of 2.4 as compared to motions occurring in Sea State 3.

5. Accelerations in Sea State 4 and 6 are severe enough to indicate that crew discomfort could be a problem. RMS levels of approximately 0.4 G's are reached at the bow and 0.25 G's at the CG.

6. Heave does not vary much with speed, while pitch and accelerations increase with speed in the 6 to 18 kt range.

7. The largest impact pressure measured on the wet deck at a point 63 percent of the cushion length forward of the transom was 1.6 psi (1.1 x 10^4 Newtons/m^2). It occurred in Sea State 4 at a model speed of 14 kts.

8. At hump speed, the calm water drag of the ANVCE ACV with its higher cushion pressure and deeper skirt is about 1.4 times as large as that of the AALC ACV which has a similar hull configuration. At cruising speed (approximately 15 kts on the model) drag of the ANVCE craft is 1.5 times larger than that of the AALC design.

9. The unit pitch response of the ANVCE model is less than that of the AALC model and the unit heave response is about equal for the two craft.

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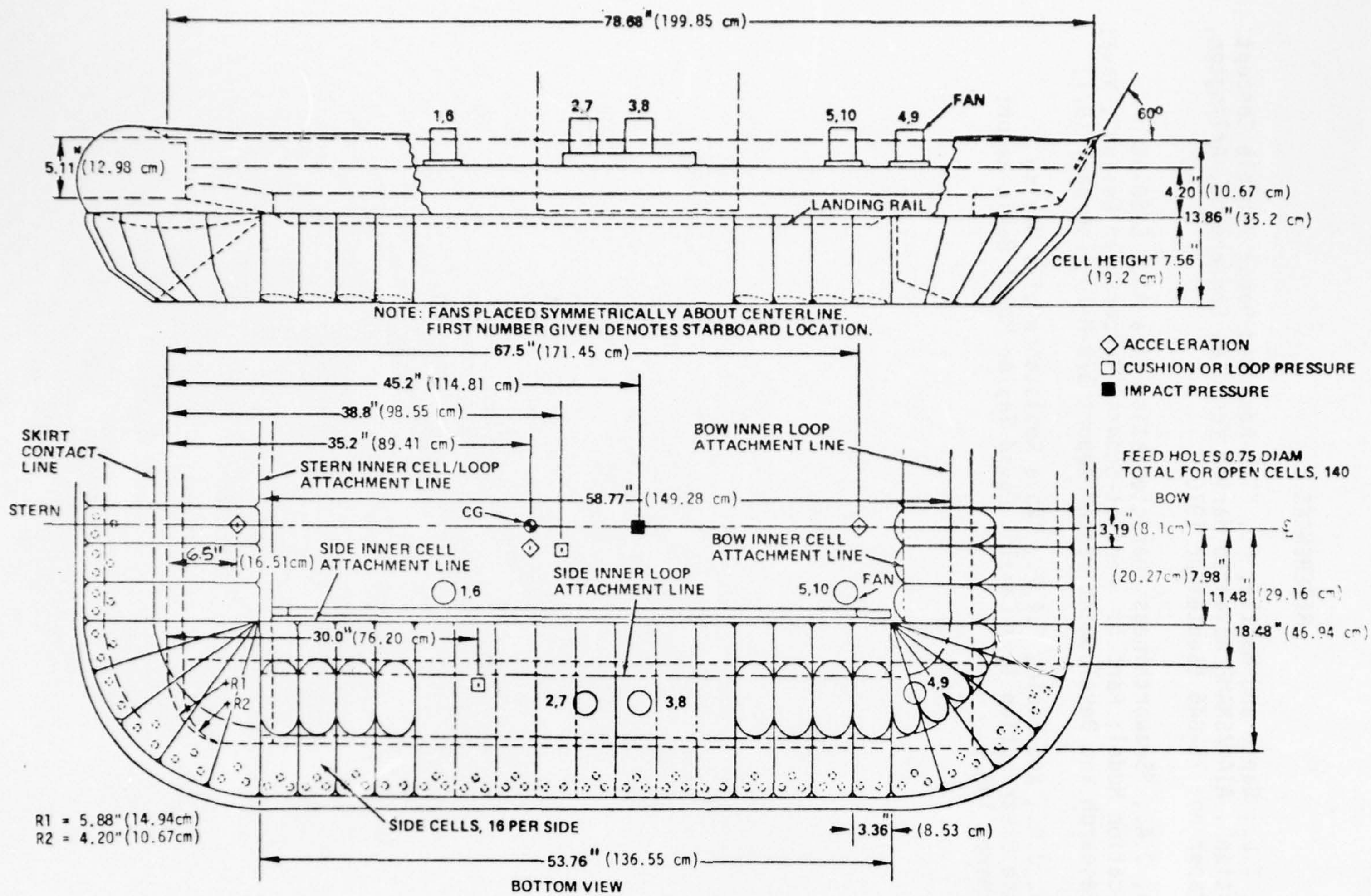


Figure 1 - Sketch of Model Showing Fan and Transducer Arrangement

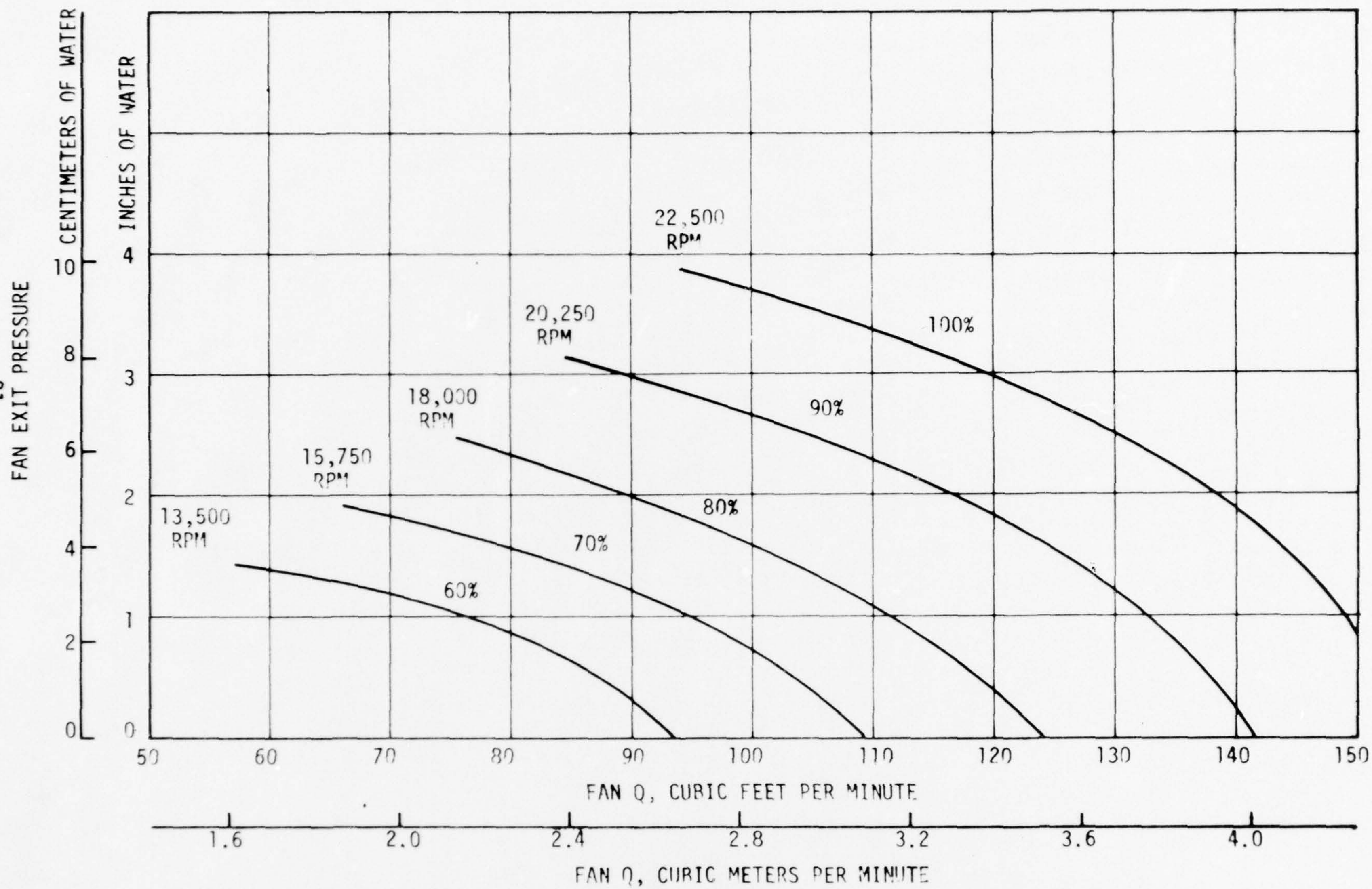


Figure 2 - Fan Characteristics for Various Speeds

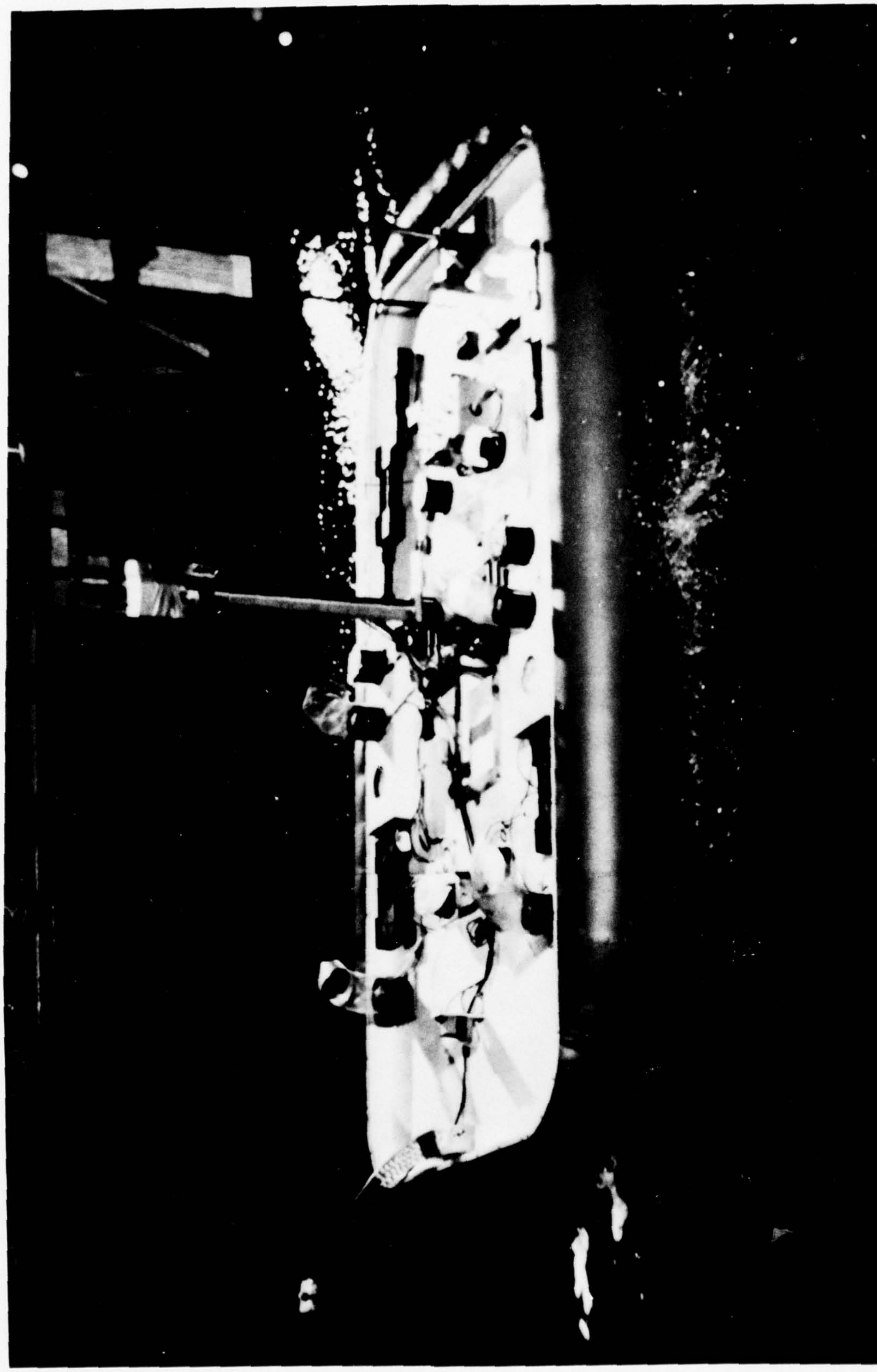


Figure 3 - Setup for Towing Tank Experiments

Figure 4 - Samples of Wave Spectra from Measurements Made During Experiments

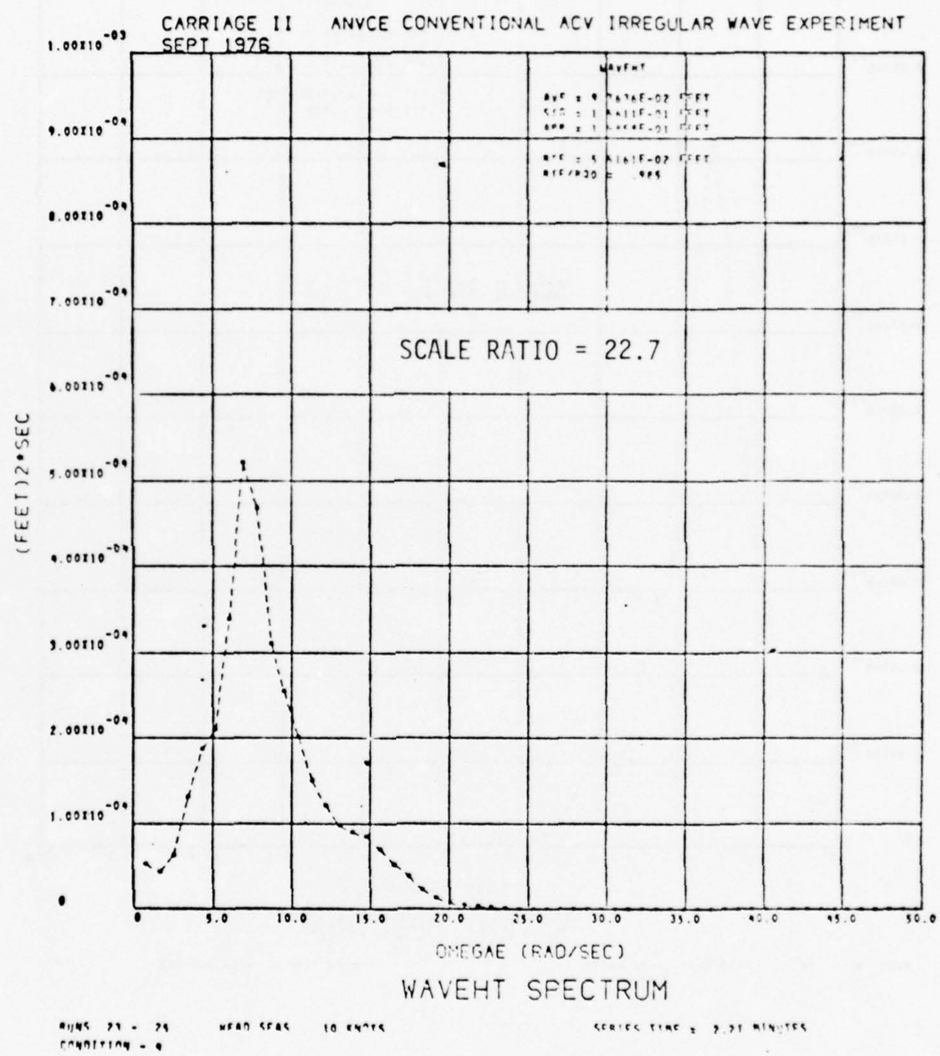


Figure 4a - Sea State 3, Model Speed 10.0 Knots

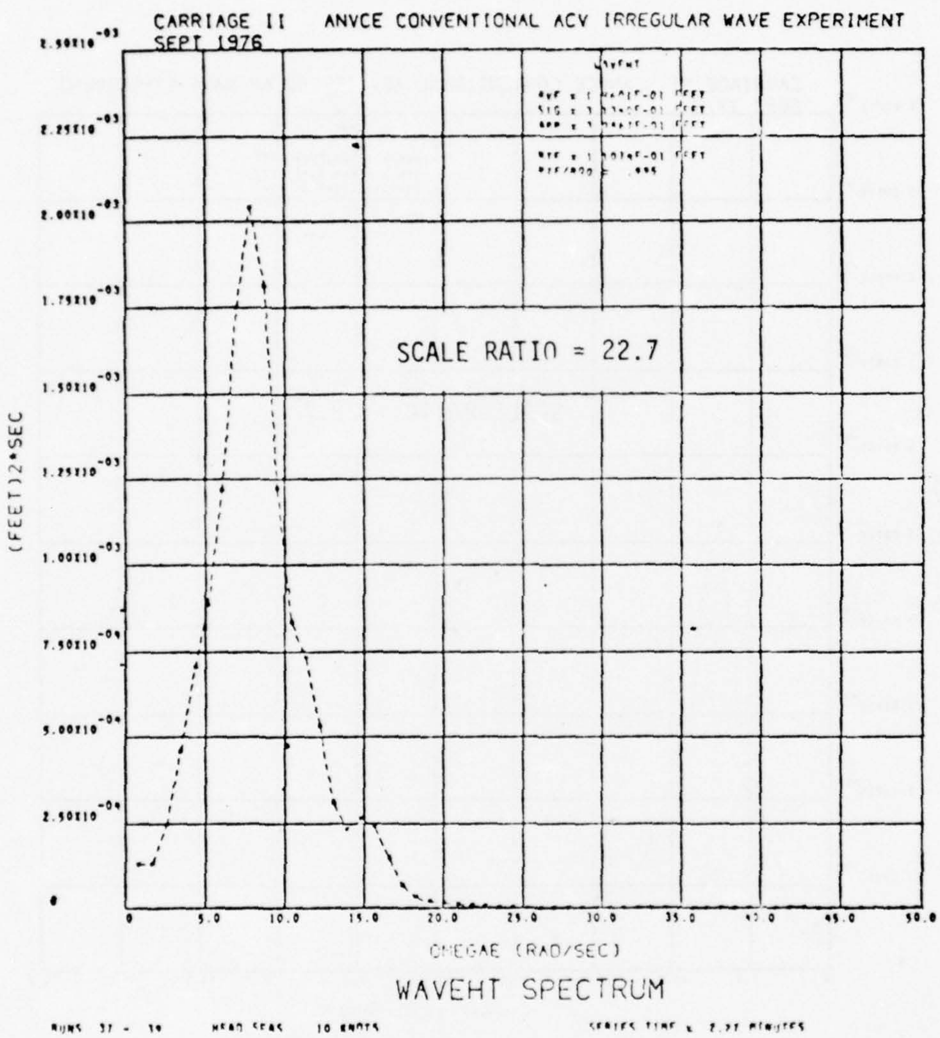


Figure 4b - Sea State 4, Model Speed 10.0 Knots

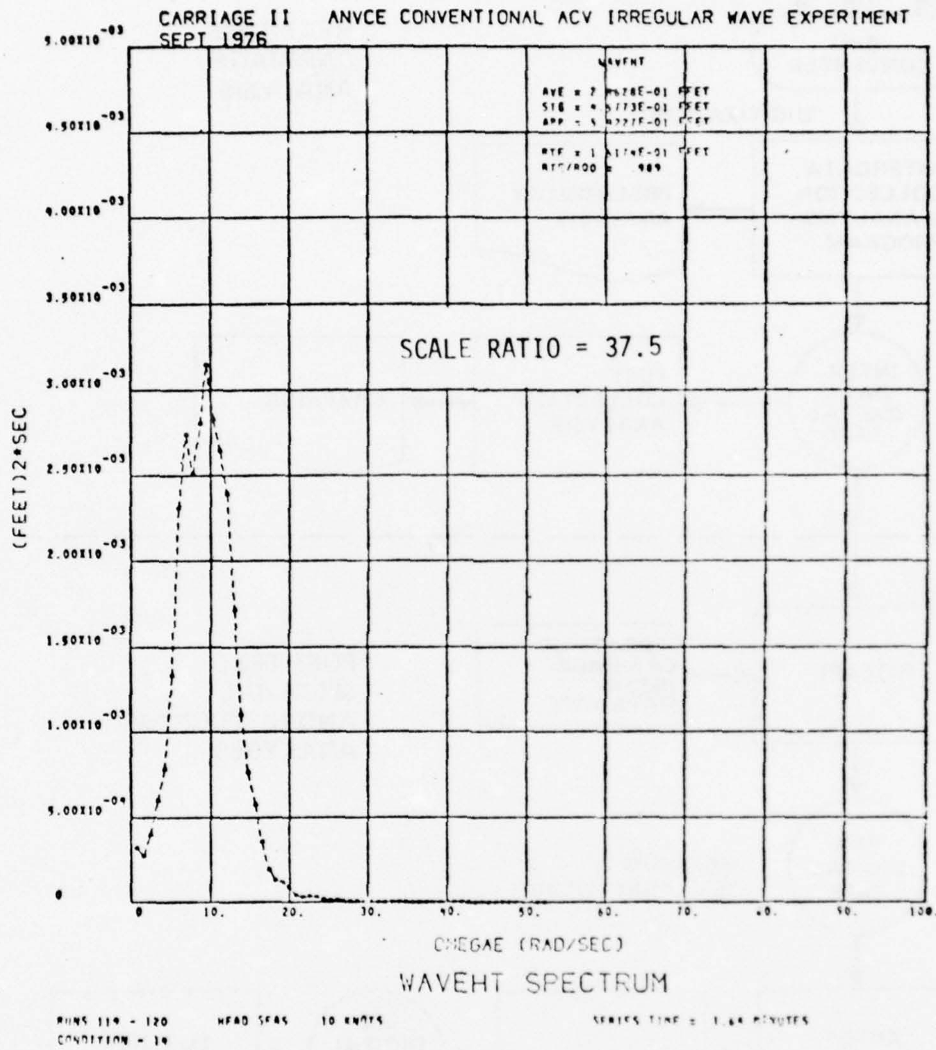


Figure 4c - Sea State 6, Model Speed 10.0 Knots

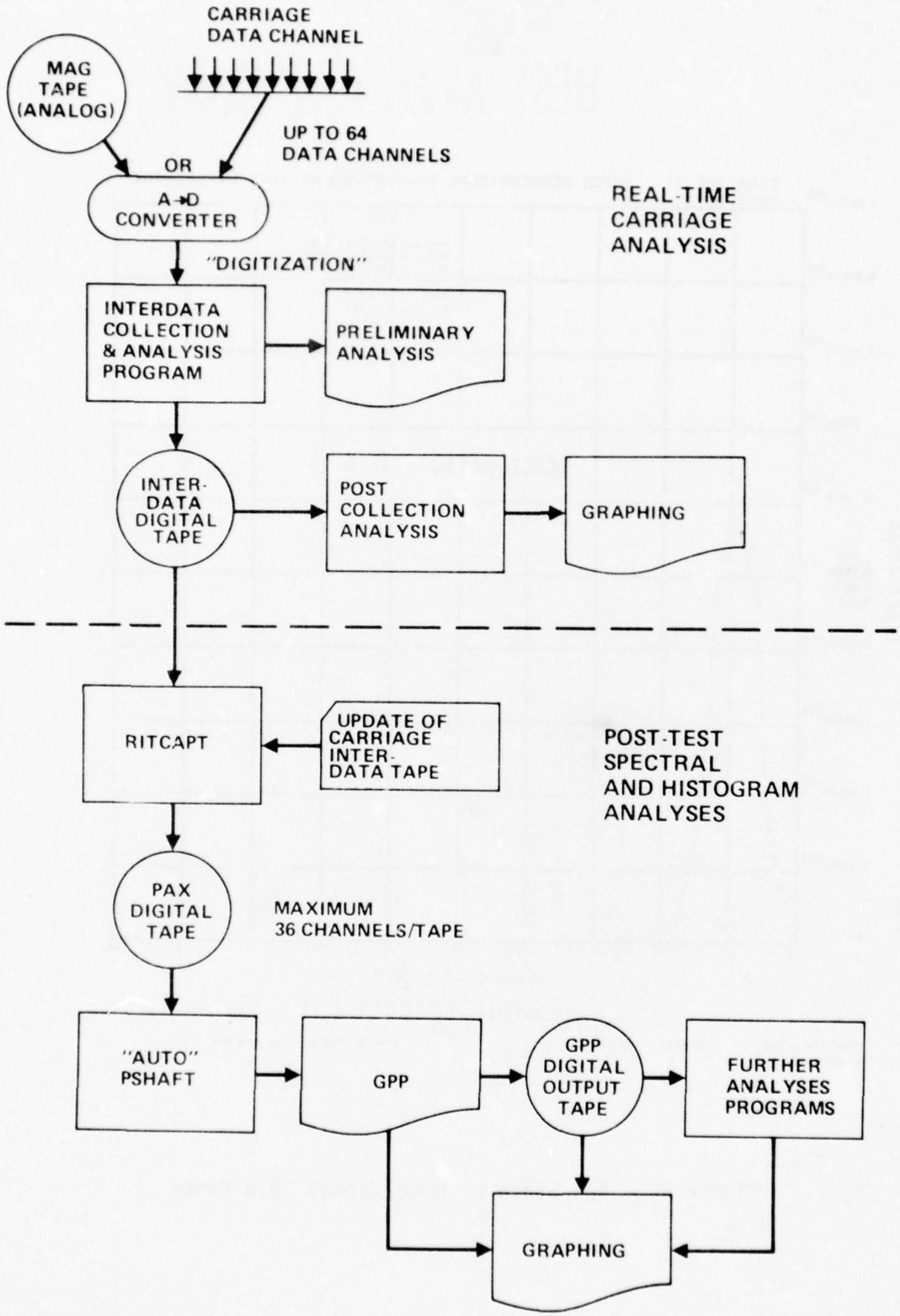


Figure 5 - Flow Chart for Computer Analysis

CARRIAGE II   ANVCE CONVENTONAL ACV IRREGULAR WAVE EXPERIMENT   2   SEPT 1976

IRREGULAR WAVES
MODEL WEIGHT : 188.2000

* CHANNELS BELOW REPEAT
10 HZ FILTERED CHANNELS
USING 6 HZ FILTERS

HEADING = 180.0 DEG

MEAS SPEED = 10.03 KNOTS
NOMN SPEED = 10.00 KNOTS

RUN NO 25

TIME: 0.000 - 41.480
RECORDS: 1 - 122

	CHAN		CALIB	GAIN	MEAN	STDDEV	ROUTNO
1	CARR VEL	KTS	5.000E 00	1.000E 00	1.003E 01	1.172E-02	1.657E-02
2	WAVE AMP	IN	5.000E 00	5.000E 00	-1.895E-03	4.761E-01	6.733E-01
3	HEAVE	IN	4.000E 01	2.000E 01	6.544E-01	5.373E-01	7.598E-01
4	PITCH	DEG	4.000E 00	2.000E 00	-6.190E-01	6.052E-01	8.559E-01
5	RBM	IN	-5.000E 00	5.000E 00	1.228E-03	1.340E-03	1.896E-03
6	BOW ACC	G	4.000E 00	4.000E 00	1.426E-02	2.051E-01	2.901E-01
7	CG ACC	G	1.600E 00	4.000E 00	2.835E-03	1.071E-01	1.514E-01
8	STERNACC	G	1.600E 00	4.000E 00	5.170E-03	1.125E-01	1.590E-01
9	DRAG	LBS	5.000E 01	5.000E 00	1.446E 01	1.078E 01	1.525E 01
10	SKIRTPRS	PSI	1.000E 00	1.000E 01	8.363E-02	8.368E-03	1.183E-02
11	CUSHPRES	PSI	1.000E 00	1.000E 01	7.386E-02	8.279E-03	1.171E-02
12	*WAVEAMP	IN	5.000E 00	5.000E 00	-1.108E-03	4.892E-01	6.918E-01
13	*HEAVE	IN	4.000E 01	2.000E 01	6.569E-01	5.326E-01	7.533E-01
14	*PITCH	DEG	4.000E 00	2.000E 00	-6.376E-01	6.217E-01	8.793E-01
15	*RBM	IN	-5.000E 00	5.000E 00	-2.813E-03	4.629E-04	6.546E-04
16	*BOW ACC	G	4.000E 00	4.000E 00	1.494E-02	2.097E-01	2.966E-01
17	*CG ACC	G	1.600E 00	4.000E 00	3.946E-03	1.087E-01	1.538E-01
18	*STN ACC	G	1.600E 00	4.000E 00	5.318E-03	1.143E-01	1.617E-01
19	*DRAG	LBS	5.000E 01	5.000E 00	1.477E 01	1.111E 01	1.571E 01
20	*SKRTPRS	PSI	1.000E 00	1.000E 01	8.376E-02	8.201E-03	1.160E-02
21	*CUSHPRS	PSI	1.000E 00	1.000E 01	7.187E-02	8.004E-03	1.132E-02

RUN 25.

NO OF CYCLES = 61
AVERAGE PERIOD = 0.6706 SEC

MAX PERIOD = 1.283 SEC
AVG PERIOD = 0.671 SEC
MIN PERIOD = 0.258 SEC

MAX DBL AMP = 2.321
AVG DBL AMP = 1.165
MIN DBL AMP = 0.342

Figure 6 - Sample Computer Printout from Real-Time Analysis of Random Wave Run

CARRIAGE II   ANVCE CONVENTONAL ACV IRREGULAR WAVE EXPERIMENT   2 SEPT 1976

IRREGULAR WAVES
MODEL WEIGHT : 188.2000

* CHANNELS BELOW REPEAT
10 HZ FILTERED CHANNELS
USING 6 HZ FILTERS

HEADING = 180.0 DEG

MEAS SPEED = 10.03 KNOTS
NOMN SPEED = 10.00 KNOTS

RUNS : 23.: 0.000 - 54.060 24.: 0.000 - 41.140 25.: 0.000 - 41.480

TOTAL TIME : 136.680 SEC

	CHAN		CALIB	GAIN	MEAN	STDDEV	ROOTU0
1	CARR VEL	KTS	5.000E 00	1.000E 00	1.003E 01	2.804E-02	3.966E-02
2	WAVE AMP	IN	5.000E 00	5.000E 00	-9.649E-02	4.620E-01	6.534E-01
3	HEAVE	IN	4.000E 01	2.000E 01	6.480E-01	5.390E-01	7.623E-01
4	PITCH	DEG	4.000E 00	2.000E 00	-6.509E-01	6.006E-01	8.494E-01
5	RBM	IN	-5.000E 00	5.000E 00	4.284E-03	1.181E-03	1.670E-03
6	BOW ACC	G	4.000E 00	4.000E 00	1.416E-02	1.904E-01	2.693E-01
7	CG ACC	G	1.600E 00	4.000E 00	3.643E-03	1.012E-01	1.432E-01
8	STERNACC	G	1.600E 00	4.000E 00	5.227E-03	1.092E-01	1.544E-01
9	DRAG	LBS	5.000E 01	5.000E 00	1.426E 01	1.214E 01	1.716E 01
10	SKIRTPRS	PSI	1.000E 00	1.000E 01	8.365E-02	7.941E-03	1.123E-02
11	CUSHPRES	PSI	1.000E 00	1.000E 01	7.425E-02	7.827E-03	1.107E-02
12	*WAVEAMP	IN	5.000E 00	5.000E 00	-9.801E-02	4.748E-01	6.715E-01
13	*HEAVE	IN	4.000E 01	2.000E 01	6.514E-01	5.349E-01	7.565E-01
14	*PITCH	DEG	4.000E 00	2.000E 00	-6.699E-01	6.171E-01	8.727E-01
15	*RBM	IN	-5.000E 00	5.000E 00	-2.861E-03	4.123E-04	5.831E-04
16	*BOW ACC	G	4.000E 00	4.000E 00	1.471E-02	1.941E-01	2.746E-01
17	*CG ACC	G	1.600E 00	4.000E 00	4.658E-03	1.018E-01	1.440E-01
18	*STN ACC	G	1.600E 00	4.000E 00	5.052E-03	1.101E-01	1.557E-01
19	*DRAG	LBS	5.000E 01	5.000E 00	1.457E 01	1.251E 01	1.770E 01
20	*SKRTPRS	PSI	1.000E 00	1.000E 01	8.363E-02	7.717E-03	1.091E-02
21	*CUSHPRS	PSI	1.000E 00	1.000E 01	7.217E-02	7.498E-03	1.060E-02

Figure 7 - Sample Computer Printout from On-Carriage Analysis of Random Wave Run Grouping

Figure 8 - Sample of Complete Random Wave Run Analysis on the CDC 6700 Computer

RANDOM WAVE DATA *** RUNS 107 - 108 HEAD SEAS 10 KNOTS BELOW SEA STATE 2 *** TAPE RECORD 2

SEA STATE 4 (NOMINAL) SCAN RATE = 16.57 SAMPLES/SEC/CHAN
BELOW SEA STATE 2 (COMPUTED) SERIES TIME = 1.57 MINUTES

BEST AVAILABLE COPY

CONDITION - 14
FANS - 20.250 RPM
6 POLE - 6 HZ FILTERS

CHANNEL	12	13	14	15	16	17	18	19	20
TITLE	WAVEHT	HEAVE	PITCH	RDM	BOWACC	CG ACC	STRNAC	DRAG	SKPTPR
UNIT	FEET	FEET	DEG	FEET	G	G	G	LBS	LBS/FT2
SCALE FACTOR	8.3333E-02	8.3333E-02	1.0000E+00	8.3333E-02	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.4409E+02
CAL (PU/VT)	1.0000E+00	2.0000E+00	2.0000E+00	-1.0000E+00	1.0000E+00	4.0000E-01	4.0000E-01	1.0000E+01	1.0000E-01
CAL (VT/CT)	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00
ATTENUATION	X	X	X	X	X	X	X	X	X
SERIES MEAN	-4.5541E-03	3.6724E-02	1.5486E-01	7.4041E-02	-2.9838E-04	4.4967E-04	-1.6567E-03	9.8766E+00	7.3287E+00
SERIES ROOTCC	6.6695E-02	5.8313E-02	6.0975E-01	1.4682E-01	2.2782E-01	1.0957E-01	8.6829E-02	8.7491E+00	8.1234E-01

FILE	RUN	CAL (PU/VT)								
107	107	1.0000E+00	2.0000E+00	2.0000E+00	-1.0000E+00	1.0000E+00	4.0000E-01	4.0000E-01	1.0000E+01	1.0000E-01
108	108	1.0000E+00	2.0000E+00	2.0000E+00	-1.0000E+00	1.0000E+00	4.0000E-01	4.0000E-01	1.0000E+01	1.0000E-01

FILE	RUN	MEAN VALUES								
107	107	-5.9332E-03	4.0266E-02	1.6802E-01	7.7031E-02	-5.2569E-04	4.5016E-04	-1.6297E-03	9.7544E+00	7.3639E+00
108	108	-3.1157E-03	3.3033E-02	1.4113E-01	7.0859E-02	-6.1277E-05	4.4915E-04	-1.6849E-03	1.0004E+01	7.2912E+00

FILE	RUN	ROOTCC VALUES								
107	107	6.5709E-02	5.7163E-02	5.8812E-01	1.4028E-01	2.2019E-01	1.0654E-01	8.6388E-02	8.9235E+00	7.9928E-01
108	108	6.7737E-02	5.9484E-02	6.3152E-01	1.5334E-01	2.3592E-01	1.1265E-01	8.7236E-02	8.5634E+00	8.2574E-01

Figure 8 - Sheet a

RUNS 107 - 108 HEAD SEAS 10 KNOTS BELOW SEA STATE 2
CONDITION - 14
FANS - 20.250 RPM
6 POLE - 6 HZ FILTERS

SEA STATE 4 (NOMINAL) 52.72 DEGREES OF FREEDOM
SERIES TIME = 1.57 MINUTES NO OF SPLICES / SERIES = 1

STATISTICAL PROPERTIES

CHANNEL TITLE UNIT	12 WAVEHT FEET	13 HEAVE FEET	14 PITCH DEG	15 RBM FEET	16 BOWACC G	17 CG ACC G	18 STRNAC G	19 DRAG LBS	20 SKRTPR LBS/FT2
ROOT E	6.5237E-02	5.6487E-02	6.0774E-01	1.4642E-01	2.2782E-01	1.0957E-01	8.6815E-02	8.6851E+00	6.1118E-01
ROOT 00	6.6695E-02	5.8313E-02	6.0975E-01	1.4642E-01	2.2782E-01	1.0957E-01	8.6829E-02	8.7491E+00	6.1234E-01
AVERAGE	1.1547E-01	9.9382E-02	1.0757E+00	2.5916E-01	4.0325E-01	1.9334E-01	1.5366E-01	1.5373E+01	1.4358E+00
SIGNIFICANT	1.8462E-01	1.5986E-01	1.7199E+00	4.1436E-01	6.4474E-01	3.1009E-01	2.4569E-01	2.4579E+01	2.2956E+00
AVE.HIGH.1/10	2.3480E-01	2.0335E-01	2.1879E+00	5.2712E-01	8.2016E-01	3.9446E-01	3.1253E-01	3.1266E+01	2.9202E+00
HI. EXP. 100	2.7922E-01	2.4177E-01	2.6011E+00	6.2666E-01	9.7508E-01	4.6897E-01	3.7157E-01	3.7172E+01	3.4719E+00
ROOTE/ROOT00	9.7814E-01	9.6868E-01	9.9671E-01	9.9724E-01	9.9999E-01	9.9999E-01	9.9984E-01	9.9269E-01	9.9857E-01

POWER SPECTRA

SPECTRUM SCALE	1.0000E-03	1.0000E-03	1.0000E-01	5.0000E-03	1.0000E-02	2.0010E-03	2.0300E-03	1.0000E+01	2.0000E-01
SPECTRUM PEAK	5.5232E-04	6.6353E-04	8.3129E-02	4.3712E-03	9.7495E-03	1.5925E-03	1.0023E-03	8.8287E+00	1.0998E-01
PEAK FREQUENCY	6.9813E+00	6.9813E+00	6.9813E+00	8.7266E+00	8.7266E+00	8.7266E+00	6.9813E+00	1.6581E+01	7.8540E+00

OMEGAE (RAD/SEC)	WAVEHT (FEET)2*SEC	HEAVE (FEET)2*SEC	PITCH (DEG)2*SEC	RBM (FEET)2*SEC	BOWACC (G)2*SEC	CG ACC (G)2*SEC	STRNAC (G)2*SEC	DRAG (LBS)2*SEC	SKRTPR (PSF)2*SEC
.873	1.1047E-04	1.1878E-04	3.2290E-03	6.9065E-05	1.8218E-06	1.8421E-07	2.3206E-06	3.9087E-01	2.1053E-03
1.745	9.0798E-05	1.0821E-04	3.7533E-03	6.0204E-05	-5.6260E-07	1.1871E-06	4.0050E-06	3.2301E-01	2.1200E-03
2.618	1.1603E-04	1.4154E-04	3.7854E-03	7.2266E-05	1.8852E-05	1.1560E-05	1.3960E-05	2.4905E-01	2.6803E-03
3.491	1.5326E-04	1.7687E-04	4.4450E-03	9.2187E-05	3.6184E-05	3.0596E-05	3.7134E-05	2.0610E-01	4.3044E-03
4.363	1.9814E-04	2.3503E-04	1.0209E-02	1.9726E-04	2.1610E-04	1.1391E-04	1.2863E-04	3.3199E-01	9.3487E-03
5.236	3.0235E-04	3.0887E-04	2.7546E-02	6.4724E-04	9.4250E-04	3.6479E-04	3.5360E-04	7.1637E-01	2.1903E-02
6.109	4.5066E-04	6.0523E-04	5.8284E-02	1.8108E-03	3.0378E-03	8.6363E-04	7.2655E-04	1.7201E+00	5.2392E-02
6.981	5.5233E-04	6.6353E-04	8.3129E-02	3.1950E-03	5.8683E-03	1.3628E-03	1.0023E-03	3.1792E+00	9.1151E-02
7.854	5.5219E-04	5.2438E-04	8.1302E-02	4.0009E-03	8.1156E-03	1.5571E-03	9.9940E-04	4.7100E+00	1.0998E-01
8.727	5.5039E-04	3.6424E-04	6.5491E-02	4.3712E-03	9.7495E-03	1.5925E-03	5.7106E-04	6.2120E+00	1.0509E-01
9.599	4.5943E-04	2.2066E-04	4.1258E-02	3.4725E-03	8.2350E-03	1.2851E-03	2.5282E-04	5.6405E+00	7.5166E-02
10.472	2.7107E-04	9.5134E-05	1.6652E-02	1.7632E-03	4.6363E-03	7.5504E-04	7.2153E-05	3.6335E+00	4.1394E-02
11.345	1.9634E-04	4.6454E-05	7.3133E-03	1.0078E-03	3.0737E-03	5.4544E-04	3.3216E-05	2.9141E+00	3.0535E-02
12.217	1.7071E-04	3.2106E-05	4.5753E-03	7.9128E-04	2.5341E-03	5.1825E-04	4.4989E-05	2.9621E+00	2.5955E-02
13.090	1.2758E-04	2.2333E-05	2.3200E-03	6.0599E-04	2.2137E-03	5.2013E-04	8.3460E-05	3.2715E+00	2.1445E-02
13.963	1.1960E-04	1.7409E-05	2.3742E-03	5.0974E-04	1.9816E-03	5.2113E-04	1.1778E-04	3.9561E+00	1.8769E-02
14.835	1.4261E-04	1.4292E-05	1.3924E-03	4.8175E-04	1.9307E-03	5.5268E-04	1.8654E-04	5.8046E+00	1.7655E-02
15.708	1.4157E-04	1.2430E-05	1.6589E-03	4.7260E-04	1.8972E-03	5.7738E-04	2.7196E-04	8.0548E+00	1.5739E-02
16.581	1.0196E-04	7.9134E-06	1.2071E-03	3.5319E-04	1.3974E-03	4.0499E-04	2.7905E-04	8.8287E+00	1.2028E-02
17.453	7.1047E-05	3.7753E-06	7.4842E-04	2.1648E-04	7.6195E-04	2.2332E-04	3.1309E-04	8.3475E+00	7.6645E-03
18.326	4.2621E-05	2.1961E-06	4.7642E-04	1.3419E-04	4.6307E-04	1.5938E-04	3.2130E-04	7.0686E+00	6.2543E-03
19.199	2.5593E-05	1.4113E-06	2.5443E-04	9.7413E-05	3.6979E-04	1.1944E-04	2.6603E-04	5.1148E+00	5.0802E-03
20.071	2.2378E-05	1.0451E-06	1.5934E-04	7.1041E-05	2.4640E-04	9.9165E-05	2.7248E-04	2.5252E+00	3.8753E-03
20.944	1.4816E-05	9.3538E-07	1.6052E-04	4.0985E-05	1.2000E-04	9.3854E-05	2.7491E-04	6.5635E-01	3.3955E-03
21.817	9.9097E-06	8.9623E-07	1.8495E-04	2.7567E-05	8.3243E-05	1.1379E-04	2.4315E-04	1.6703E-01	4.1885E-03
22.689	7.5321E-06	7.6123E-07	2.0389E-04	2.2547E-05	9.2455E-05	1.1458E-04	2.1405E-04	7.4888E-02	4.8615E-03
23.562	6.5698E-06	6.1737E-07	1.8517E-04	1.8538E-05	1.1944E-04	1.1483E-04	2.1320E-04	6.9364E-02	5.1785E-03
24.435	5.6310E-06	6.2253E-07	1.8700E-04	1.5502E-05	1.4890E-04	1.2672E-04	2.0599E-04	7.1296E-02	6.1189E-03
25.307	3.3377E-06	6.2232E-07	1.8048E-04	1.0504E-05	1.4183E-04	1.2919E-04	1.9391E-04	4.7645E-02	6.2946E-03
26.180	1.8631E-06	5.4649E-07	1.4629E-04	6.7679E-06	1.2137E-04	1.2650E-04	1.8433E-04	3.7126E-02	5.5701E-03
27.053	1.6709E-06	4.0936E-07	1.2277E-04	5.6873E-06	1.1022E-04	1.1418E-04	1.7448E-04	3.7337E-02	4.8248E-03

Figure 8 - Sheet b

RESPONSE AMPLITUDE OPERATORS

5 PERCENT AMPLITUDE RANGES

FREQ. RANGE	WAVEHT	HEAVE	PITCH	RBM	BOWACC	CG ACC	STRNAC	DRAG	SKPTPR
1	1.75-18.33	1.75-11.34	3.49-12.22	5.24-16.58	5.24-17.45	4.36-29.67	4.36-10.47	5.24-20.94	4.36-18.33
2	0.00- 0.00	0.00- 0.00	0.00- 0.00	0.00- 0.00	0.00- 0.00	0.00- 0.00	13.09-31.42	0.00- 0.00	24.43-26.18

OMEGAE	WAVEHT SPECTRUM	HEAVE / WAVEHT	PITCH / WAVEHT	RBM / WAVEHT	BOWACC / WAVEHT	CG ACC / WAVEHT	STRNAC / WAVEHT	DRAG / WAVEHT	SKPTPR / WAVEHT
.873	1.1047E-04	1.0752E+00	2.9230E+01	6.2571E-01	1.6492E-02	1.6676E-03	2.1007E-02	3.5787E+03	1.2258E+01
1.745	9.0798E-05	1.1918E+00	4.1137E+01	6.6376E-01	-6.1361E-03	1.3074E-02	4.4109E-02	3.5575E+03	2.3748E+01
2.618	1.1603E-04	1.2199E+00	3.2626E+01	6.7224E-01	1.6248E-01	9.9632E-02	1.2032E-01	2.1465E+03	2.3101E+01
3.491	1.5306E-04	1.1959E+00	2.9041E+01	5.8923E-01	2.3540E-01	1.9939E-01	2.4261E-01	1.3465E+03	2.8122E+01
4.363	1.9814E-04	1.[illegible]E+00	5.1519E+01	9.9532E-01	1.[illegible]E+00	5.7437E-01	6.4015E-01	1.6755E+03	4.7181E+01
5.236	3.0255E-04	1.3184E+00	9.1044E+01	2.1393E+00	3.1151E+00	1.2057E+00	1.1386E+00	2.3677E+03	7.2395E+01
6.109	4.5006E-04	1.3430E+00	1.2933E+02	4.0141E+00	6.7408E+00	1.9154E+00	1.5122E+00	7.8158E+03	1.1626E+02
6.981	5.5233E-04	1.2013E+00	1.5001E+02	5.7845E+00	1.0625E+01	2.4673E+00	1.9147E+00	5.7560E+03	1.6503E+02
7.854	5.5219E-04	9.5584E-01	1.4724E+02	7.2455E+00	1.4697E+01	2.8139E+00	1.6298E+00	8.5237E+03	1.9918E+02
8.727	5.5039E-04	6.6183E-01	1.1399E+02	7.9420E+00	1.7714E+01	2.9934E+00	1.0376E+00	1.1287E+04	1.9794E+02
9.599	4.5363E-04	4.8013E-01	8.9763E+01	7.5550E+00	1.7317E+01	2.7959E+00	5.7190E-01	1.2272E+04	1.6354E+02
10.472	2.7107E-04	3.5118E-01	6.1431E+01	6.5047E+00	1.7104E+01	2.7854E+00	2.6618E-01	1.3404E+04	1.5492E+02
11.345	1.9654E-04	2.3398E-01	3.5469E+01	5.7032E+00	1.5482E+01	2.7473E+00	1.5219E-01	1.4679E+04	1.5380E+02
12.217	1.7071E-04	1.8807E-01	2.6501E+01	4.5352E+00	1.5194E+01	3.0394E+00	2.5354E-01	1.7351E+04	1.5204E+02
13.090	1.2756E-04	1.7525E-01	2.2944E+01	4.7431E+00	1.7352E+01	4.0766E+00	6.5418E-01	2.5643E+04	1.6902E+02
13.963	1.1969E-04	1.4353E-01	1.9836E+01	4.2547E+00	1.6556E+01	4.3539E+00	9.8393E-01	3.7052E+04	1.5691E+02
14.835	1.4261E-04	1.0022E-01	1.3270E+01	3.3791E+00	1.3257E+01	3.8754E+00	1.3090E+00	4.0702E+04	1.2380E+02
15.708	1.4157E-04	8.7799E-02	1.1718E+01	3.3343E+00	1.3401E+01	4.0826E+00	1.3210E+00	5.5936E+04	1.1824E+02
16.581	1.1196E-04	7.7051E-02	1.1353E+01	3.4642E+00	1.3725E+01	3.9770E+00	2.7368E+00	8.6598E+04	1.1796E+02
17.453	7.1047E-05	5.3147E-02	1.1097E+01	3.0459E+00	1.0725E+01	3.1519E+00	4.4058E+00	1.1749E+05	1.0788E+02
18.326	4.2021E-05	5.2261E-02	1.1034E+01	3.1933E+00	1.1020E+01	3.8071E+00	7.5461E+00	1.6921E+05	1.4884E+02
19.199	2.5593E-05	5.5153E-02	9.9413E+00	3.9042E+00	1.4449E+01	4.6670E+00	1.0379E+01	1.9995E+05	1.9950E+02
20.071	2.2378E-05	4.6731E-02	7.1006E+00	3.1746E+00	1.1011E+01	4.4314E+00	1.2287E+01	1.1284E+05	1.7317E+02
20.944	1.4816E-05	5.6522E-02	1.0834E+01	2.7643E+00	9.0391E+00	6.7403E+00	1.9556E+01	4.4300E+04	2.2918E+02
21.817	9.9037E-06	9.6440E-02	1.3684E+01	2.7418E+00	9.0256E+00	1.1492E+01	2.4037E+01	1.8860E+04	4.2267E+02
22.689	7.5321E-06	1.0106E-01	2.7069E+01	2.3935E+00	1.7322E+01	1.5212E+01	2.9418E+01	9.3475E+03	6.4543E+02
23.562	6.5538E-06	9.3972E-02	2.8185E+01	2.4217E+00	1.8180E+01	1.7479E+01	7.2452E+01	1.2559E+04	7.6623E+02
24.435	5.6308E-06	1.1056E-01	3.2501E+01	2.7530E+00	2.5443E+01	2.2504E+01	3.6564E+01	1.2662E+04	1.0467E+03
25.307	3.3377E-06	1.8645E-01	5.4065E+01	3.1470E+00	4.2493E+01	3.8707E+01	5.5102E+01	1.4275E+04	1.8950E+03
26.180	1.8631E-06	2.9333E-01	7.8517E+01	3.6325E+00	5.5147E+01	6.7357E+01	9.8976E+01	1.9327E+04	2.9595E+03
27.053	1.6709E-06	2.4510E-01	7.3475E+01	3.4033E+00	6.5166E+01	6.8335E+01	1.0443E+02	2.2346E+04	2.8876E+03
27.925	1.4436E-06	2.3466E-01	7.4607E+01	3.0261E+00	6.6209E+01	6.5841E+01	9.3960E+01	2.1227E+04	2.9407E+03
28.798	1.3306E-06	2.0472E-01	6.8149E+01	2.5715E+00	6.8401E+01	6.4237E+01	7.7730E+01	1.7881E+04	3.0411E+03
29.671	1.3241E-06	1.8647E-01	6.2101E+01	2.5834E+00	7.8747E+01	6.3554E+01	6.5434E+01	1.7932E+04	2.8859E+03
30.543	1.0657E-06	2.1664E-01	6.9351E+01	2.8773E+00	9.3340E+01	5.7635E+01	6.2423E+01	1.7145E+04	2.7340E+03
31.416	8.5714E-07	2.3434E-01	6.4174E+01	2.4134E+00	8.9415E+01	6.3737E+01	5.3344E+01	1.4994E+04	2.2997E+03
32.289	7.6072E-07	2.4421E-01	6.5731E+01	1.8113E+00	8.2177E+01	5.9839E+01	5.6135E+01	1.5637E+04	2.0739E+03
33.161	5.5366E-07	3.4536E-01	8.5767E+01	2.1137E+00	9.6743E+01	6.9931E+01	6.0268E+01	1.9048E+04	2.4660E+03
34.034	4.1369E-07	4.4206E-01	8.4866E+01	2.8031E+00	1.0437E+02	7.5666E+01	6.7830E+01	1.7435E+04	3.7107E+03
34.907	4.0032E-07	4.1615E-01	6.5576E+01	2.8444E+00	9.1443E+01	6.2043E+01	5.1488E+01	1.4315E+04	3.5424E+03
35.779	3.4433E-07	4.2065E-01	5.7092E+01	2.5987E+00	7.2981E+01	5.0923E+01	4.3319E+01	1.1575E+04	3.6094E+03
36.652	2.7450E-07	4.8177E-01	6.5730E+01	2.4543E+00	5.2346E+01	4.5942E+01	4.6812E+01	1.3068E+04	3.6750E+03
37.525	2.2547E-07	5.2573E-01	5.4553E+01	2.5656E+00	3.8386E+01	4.0972E+01	5.1270E+01	1.3940E+04	3.3655E+03
38.397	2.0933E-07	5.4676E-01	3.1222E+01	2.1441E+00	3.1558E+01	2.4730E+01	3.4742E+01	1.3744E+04	2.6774E+03
39.270	2.0349E-07	5.5272E-01	3.1247E+01	1.4514E+00	3.3774E+01	2.6241E+01	2.6974E+01	1.2203E+04	2.4557E+03
40.143	1.0157E-07	7.1043E-01	4.8917E+01	1.5903E+00	4.4477E+01	4.0774E+01	4.7187E+01	1.9214E+04	3.2523E+03
41.015	1.2609E-07	8.6016E-01	5.3723E+01	1.8262E+00	5.2798E+01	4.9756E+01	6.2215E+01	2.2314E+04	3.7776E+03
41.888	1.0932E-07	9.5596E-01	4.7759E+01	2.0972E+00	5.8466E+01	4.3424E+01	5.2907E+01	1.7556E+04	3.5577E+03
42.761	8.7127E-08	1.1917E+00	2.3211E+01	2.4981E+00	8.1396E+01	7.0938E+01	7.2333E+01	1.5715E+04	4.1181E+03

Figure 8 - Sheet c

NONDIMENSIONAL TRANSFER FUNCTIONS

5 PERCENT AMPLITUDE RANGES

		WAVEHT	HEAVE	PITCH*	RBM	BOWACC	CG ACC	STRNAC	DRAG	SKRTPR
FREQ.	RANGE 1	1.75-18.33	1.75-11.34	3.49-12.22	5.24-16.58	5.24-17.45	4.36-29.67	4.36-10.47	5.24-20.94	4.36-18.33
	2	0.00- 0.00	0.00- 0.00	0.00- 0.00	0.00- 0.00	0.00- 0.00	0.00- 0.00	13.09-31.42	0.00- 0.00	24.43-26.18
L/LAM	OMEGAE	WAVEHT SPECTRUM	HEAVE / WAVEHT	PITCH / WSLOPE	RBM / WAVEHT	BOWACC / WAVEHT	CG ACC / WAVEHT	STRNAC / WAVEHT	DRAG / WAVEHT	SKRTPR / WAVEHT
.01	.873	1.1047E-04	1.0369E+00	7.1776E+00	7.9070E-01	5.4300E+00	1.7256E+00	6.1283E+00	1.8901E+00	4.9605E+00
.04	1.745	9.0798E-05	1.0917E+00	2.9595E+00	8.1428E-01	8.3207E-01	1.2087E+00	2.2201E+00	1.8952E+00	5.4905E+00
.06	2.618	1.1103E-04	1.1045E+00	1.4740E+00	7.8920E-01	1.8979E+00	1.4829E+00	1.5296E+00	1.4721E+00	5.4613E+00
.10	3.491	1.5326E-04	1.0750E+00	9.3793E-01	7.6751E-01	1.2949E+00	1.1815E+00	1.3017E+00	1.1660E+00	6.0257E+00
.13	4.363	1.9814E-04	1.0831E+00	9.2845E-01	9.9776E-01	1.7663E+00	1.2823E+00	1.3627E+00	1.3006E+00	7.8049E+00
.16	5.236	3.0235E-04	1.1442E+00	9.7358E-01	1.4626E+00	2.0770E+00	1.2837E+00	1.2805E+00	1.5461E+00	9.6681E+00
.20	6.109	4.5066E-04	1.1539E+00	9.5276E-01	2.0045E+00	2.2404E+00	1.1946E+00	1.0957E+00	1.9631E+00	1.2252E+01
.23	6.981	5.5233E-04	1.0361E+00	8.6854E-01	2.4051E+00	2.1535E+00	1.0377E+00	8.8998E-01	2.4107E+00	1.4597E+01
.27	7.854	5.5219E-04	9.7818E-01	7.4180E-01	2.6917E+00	2.0012E+00	8.7659E-01	6.6521E-01	2.9346E+00	1.6036E+01
.31	8.727	5.5039E-04	8.1351E-01	5.8560E-01	2.8181E+00	1.7796E+00	7.1923E-01	4.3069E-01	3.3757E+00	1.5701E+01
.35	9.599	4.5963E-04	6.9289E-01	4.5268E-01	2.7486E+00	1.4791E+00	5.8430E-01	2.6424E-01	3.5200E+00	1.4531E+01
.39	10.472	2.7107E-04	5.9261E-01	3.3697E-01	2.5504E+00	1.2144E+00	4.9005E-01	1.5149E-01	3.6788E+00	1.4143E+01
.43	11.345	1.9854E-04	4.8372E-01	2.3706E-01	2.2530E+00	9.8444E-01	4.1470E-01	9.7605E-02	3.8496E+00	1.4092E+01
.46	12.217	1.7071E-04	4.3367E-01	1.8496E-01	2.1529E+00	8.4094E-01	3.7587E-01	1.1075E-01	4.1855E+00	1.4011E+01
.50	13.090	1.2758E-04	4.1639E-01	1.5744E-01	2.1702E+00	7.8280E-01	3.7943E-01	1.5193E-01	5.0882E+00	1.4732E+01
.54	13.963	1.1969E-04	3.8682E-01	1.3578E-01	2.0637E+00	6.7204E-01	3.4463E-01	1.6384E-01	5.7767E+00	1.4229E+01
.59	14.835	1.4251E-04	3.1657E-01	1.3340E-01	1.8380E+00	5.3271E-01	2.8802E-01	1.6733E-01	6.4105E+00	1.2643E+01
.63	15.708	1.4137E-04	2.9631E-01	9.0850E-02	1.8271E+00	4.7773E-01	2.6369E-01	1.8088E-01	7.5792E+00	1.2356E+01
.67	16.581	1.0196E-04	2.7468E-01	8.5728E-02	1.8612E+00	4.3360E-01	2.3343E-01	1.9377E-01	9.3500E+00	1.2341E+01
.71	17.453	7.1047E-05	2.3364E-01	7.8139E-02	1.7456E+00	3.4617E-01	1.8756E-01	2.2190E-01	1.0891E+01	1.1802E+01
.75	18.326	4.2021E-05	2.2861E-01	7.4675E-02	1.7870E+00	3.1828E-01	1.8708E-01	2.6512E-01	1.3032E+01	1.3862E+01
.79	19.199	2.5993E-05	2.3485E-01	6.6261E-02	1.9510E+00	3.3207E-01	1.8873E-01	2.8166E-01	1.4205E+01	1.6009E+01
.83	20.071	2.2378E-05	2.1610E-01	5.3274E-02	1.7817E+00	2.6522E-01	1.6826E-01	2.7788E-01	1.0674E+01	1.4953E+01
.87	20.944	1.4816E-05	2.5792E-01	6.2572E-02	1.6632E+00	2.0891E-01	1.9058E-01	3.1621E-01	6.6878E+00	1.7202E+01
.92	21.817	9.9037E-06	3.0073E-01	7.8368E-02	1.6679E+00	2.0302E-01	2.2924E-01	3.3511E-01	4.1259E+00	2.3361E+01
.96	22.689	7.5321E-06	3.1731E-01	9.0235E-02	1.7302E+00	2.1266E-01	2.4396E-01	3.3343E-01	3.1683E+00	2.8867E+01
1.00	23.562	6.5698E-06	3.0655E-01	8.3192E-02	1.6738E+00	2.4770E-01	2.4249E-01	3.3041E-01	3.2649E+00	3.1902E+01
1.04	24.435	5.6308E-06	3.3250E-01	9.3859E-02	1.6592E+00	2.7734E-01	2.5585E-01	3.2512E-01	3.5754E+00	3.7457E+01
1.08	25.307	3.3777E-06	4.3140E-01	1.1260E-01	1.7740E+00	3.2773E-01	3.1279E-01	3.7321E-01	3.7864E+00	4.9345E+01
1.13	26.180	1.8831E-06	5.4157E-01	1.3058E-01	1.9059E+00	3.7319E-01	3.8558E-01	4.6730E-01	4.4854E+00	6.2129E+01
1.17	27.053	1.7039E-06	4.9437E-01	1.2171E-01	1.8449E+00	3.5735E-01	3.6371E-01	4.4962E-01	4.7499E+00	6.1059E+01
1.21	27.925	1.4436E-06	4.8442E-01	1.2150E-01	1.7338E+00	3.3598E-01	3.3505E-01	4.0034E-01	4.6294E+00	6.1614E+01
1.25	28.798	1.3068E-06	4.5631E-01	1.0975E-01	1.6036E+00	3.2163E-01	3.1112E-01	3.4245E-01	4.2454E+00	6.2662E+01
1.30	29.671	1.3241E-06	4.3142E-01	1.0081E-01	1.6396E+00	3.2458E-01	2.9159E-01	2.9592E-01	4.2550E+00	6.1042E+01
1.34	30.543	1.0407E-06	4.5400E-01	1.0290E-01	1.6953E+00	3.3454E-01	2.8387E-01	2.7272E-01	4.1506E+00	5.9413E+01
1.38	31.416	8.5719E-07	4.8409E-01	9.6035E-02	1.5551E+00	3.0918E-01	2.6050E-01	2.5259E-01	3.8901E+00	5.4490E+01
1.43	32.289	7.6072E-07	4.9921E-01	9.4358E-02	1.3444E+00	2.7991E-01	2.3903E-01	2.3141E-01	3.9734E+00	5.1745E+01
1.47	33.161	5.5806E-07	5.8745E-01	1.0457E-01	1.4545E+00	2.8801E-01	2.4497E-01	2.2732E-01	4.4083E+00	5.6427E+01
1.51	34.034	4.1069E-07	6.6437E-01	1.0104E-01	1.6751E+00	2.8040E-01	2.4191E-01	2.2035E-01	4.2506E+00	6.5380E+01
1.56	34.907	4.0032E-07	6.4502E-01	8.5345E-02	1.6867E+00	2.5271E-01	2.0950E-01	1.8963E-01	3.8017E+00	5.7629E+01
1.60	35.779	3.4433E-07	6.4458E-01	7.3378E-02	1.6121E+00	2.1444E-01	1.7949E-01	1.6555E-01	3.7021E+00	6.8265E+01
1.64	36.652	2.7456E-07	6.9410E-01	8.1452E-02	1.5711E+00	1.7425E-01	1.6087E-01	1.5400E-01	3.7540E+00	6.8507E+01
1.69	37.525	2.2547E-07	7.2540E-01	7.2658E-02	1.5989E+00	1.4273E-01	1.4638E-01	1.6376E-01	3.9991E+00	6.5921E+01
1.73	38.397	2.0999E-07	7.3943E-01	5.3581E-02	1.4779E+00	1.2269E-01	1.1719E-01	1.2873E-01	3.7251E+00	5.8795E+01
1.78	39.270	2.0349E-07	7.4345E-01	5.1472E-02	1.2047E+00	1.2136E-01	1.0696E-01	1.0824E-01	3.5100E+00	5.6308E+01
1.82	40.143	1.6167E-07	8.4291E-01	6.3853E-02	1.2571E+00	1.3380E-01	1.2760E-01	1.3726E-01	4.4044E+00	6.4805E+01
1.86	41.015	1.2809E-07	9.2204E-01	6.8876E-02	1.3513E+00	1.3815E-01	1.3502E-01	1.4853E-01	4.7468E+00	6.9838E+01
1.91	41.888	1.0932E-07	9.7753E-01	5.0176E-02	1.4482E+00	1.4032E-01	1.2893E-01	1.3349E-01	4.2101E+00	6.7870E+01
1.95	42.761	8.7037E-08	1.0912E+00	4.6001E-02	1.5790E+00	1.5946E-01	1.4839E-01	1.4977E-01	3.9895E+00	7.2918E+01
2.00	43.633	8.4054E-08	1.1143E+00	4.4673E-02	1.5037E+00	1.5457E-01	1.4898E-01	1.5160E-01	3.8697E+00	7.4894E+01

Figure 8 - Sheet d

RUNS 107 - 108 HEAD SEAS 10 KNOTS BELOW SEA STATE 2
CONDITION - 14
FANS - 20,250 RPM
6 POLE - 6 HZ FILTERS

STATISTICAL PROPERTIES
(COMPUTED FROM DOUBLE AMPLITUDE DISTRIBUTIONS)

CHANNEL	12	13	14	15	16	17	18	19	20
TITLE	WAVEHT	HEAVE	PITCH	RBM	BOWACC	CG ACC	STRNAC	DRAG	SKRTPR
UNIT	FEET	FEET	DEG	FEET	G	G	G	LBS	LBS/FT2
NO OB. AMPL.	129	93	106	141	141	159	176	209	59
NO DATA PTS.	1567	1567	1567	1567	1567	1557	1567	1567	1567
MEAN	-4.5541E-03	3.6728E-02	1.5486E-01	7.4041E-02	-2.9978E-04	4.4987E-04	-1.6557E-03	9.8766E+00	7.3283E+00
ROOTQJ	6.6695E-02	5.8313E-02	6.3475E-01	1.4682E-01	2.2782E-01	1.0957E-01	8.6823E-02	8.7491E+00	8.1234E-01
AVERAGE	1.2295E-01	1.0933E-01	1.1509E+00	2.4993E-01	4.1909E-01	2.0569E-01	1.6222E-01	1.5187E+01	2.7017E+00
SIGNIFICANT	1.7853E-01	1.6152E-01	1.7031E+00	3.8903E-01	6.3479E-01	3.1288E-01	2.4360E-01	2.2352E+01	2.8573E+00
AVE.HIGH.1/10	2.1048E-01	1.9037E-01	2.0437E+00	4.7962E-01	8.0110E-01	4.0259E-01	3.1236E-01	2.8857E+01	3.3583E+00
MEDIAN	1.2263E-01	1.0615E-01	1.1226E+00	2.3895E-01	4.0933E-01	1.9313E-01	1.5000E-01	1.4265E+01	2.2333E+00
MODE	1.2762E-01	7.8519E-02	1.0857E+00	2.0923E-01	2.6154E-01	1.9069E-01	1.3469E-01	1.3615E+01	1.9946E+00
MAX OB. AMPL.	2.4049E-01	2.3449E-01	2.7174E+00	5.9014E-01	9.6563E-01	5.0613E-01	5.1004E-01	3.5451E+01	3.8059E+00
MIN OB. AMPL.	3.0011E-02	3.3469E-02	3.0133E-02	5.7020E-02	1.1780E-01	6.2503E-02	4.4476E-02	2.5857E+00	1.6788E+00
MAX DATA PTS.	1.5551E-01	1.2718E-01	1.4519E+00	3.4659E-01	6.1030E-01	2.5664E-01	2.9998E-01	2.3200E+01	2.6034E+00
MIN DATA PTS.	-1.6136E-01	-1.4910E-01	-1.4779E+00	-3.3391E-01	-5.7370E-01	-3.4641E-01	-2.2006E-01	-1.5046E+01	-2.0526E+00

CHANNEL	21
TITLE	CUSHPR
UNIT	LBS/FT2
NO OB. AMPL.	43
NO DATA PTS.	1567
MEAN	5.7156E+00
ROOTQJ	7.4279E-01
AVERAGE	2.2465E+00
SIGNIFICANT	2.8519E+00
AVE.HIGH.1/10	3.3233E+00
MEDIAN	2.1556E+00
MODE	1.8667E+00
MAX OB. AMPL.	3.7356E+00
MIN OB. AMPL.	1.5631E+00
MAX DATA PTS.	1.4816E+00
MIN DATA PTS.	-2.6762E+00

Figure 8 - Sheet e

DOUBLE AMPLITUDES				DATA POINTS	
FREQUENCY DISTRIBUTION		CUMULATIVE DISTRIBUTIONS		FREQUENCY DISTRIBUTION	
WAVEHT	NO OF OCC	LESS THAN	MORE THAN	WAVEHT	NO OF OCC
0. FEET	2	0	129	-1.6E-01 FEET	7
4.0E-02 FEET	26	2	127	-1.2E-01 FEET	68
8.0E-02 FEET	34	28	101	-8.0E-02 FEET	207
1.2E-01 FEET	38	62	67	-4.0E-02 FEET	445
1.6E-01 FEET	21	100	29	6.7E-16 FEET	532
2.0E-01 FEET	8	121	8	4.0E-02 FEET	241
2.4E-01 FEET		129	0	8.0E-02 FEET	62
				1.2E-01 FEET	5
				1.6E-01 FEET	

DOUBLE AMPLITUDES				DATA POINTS	
FREQUENCY DISTRIBUTION		CUMULATIVE DISTRIBUTIONS		FREQUENCY DISTRIBUTION	
HEAVE	NO OF OCC	LESS THAN	MORE THAN	HEAVE	NO OF OCC
0. FEET	1	0	90	-1.6E-01 FEET	4
4.0E-02 FEET	27	1	89	-1.2E-01 FEET	29
8.0E-02 FEET	26	28	62	-8.0E-02 FEET	254
1.2E-01 FEET	23	54	36	-4.0E-02 FEET	466
1.6E-01 FEET	12	77	13	6.7E-16 FEET	506
2.0E-01 FEET	1	89	1	4.0E-02 FEET	271
2.4E-01 FEET		90	0	8.0E-02 FEET	34
				1.2E-01 FEET	3
				1.6E-01 FEET	

DOUBLE AMPLITUDES				DATA POINTS	
FREQUENCY DISTRIBUTION		CUMULATIVE DISTRIBUTIONS		FREQUENCY DISTRIBUTION	
PITCH	NO OF OCC	LESS THAN	MORE THAN	PITCH	NO OF OCC
0. DEG	2	0	106	-1.6E+00 DEG	6
4.0E-01 DEG	26	2	104	-1.2E+00 DEG	62
8.0E-01 DEG	31	28	78	-8.0E-01 DEG	207
1.2E+00 DEG	29	59	47	-4.0E-01 DEG	447
1.6E+00 DEG	15	88	18	1.2E-14 DEG	559
2.0E+00 DEG	1	103	3	4.0E-01 DEG	247
2.4E+00 DEG	2	104	2	8.0E-01 DEG	36
2.8E+00 DEG		106	0	1.2E+00 DEG	4
				1.6E+00 DEG	

DOUBLE AMPLITUDES				DATA POINTS	
FREQUENCY DISTRIBUTION		CUMULATIVE DISTRIBUTIONS		FREQUENCY DISTRIBUTION	
RBM	NO OF OCC	LESS THAN	MORE THAN	RBM	NO OF OCC
0. FEET	11	0	141	-4.0E-01 FEET	4
8.0E-02 FEET	22	11	130	-3.2E-01 FEET	12
1.6E-01 FEET	38	33	108	-2.4E-01 FEET	91
2.4E-01 FEET	28	71	70	-1.6E-01 FEET	221
3.2E-01 FEET	30	99	42	-8.0E-02 FEET	497
4.0E-01 FEET	6	129	12	1.3E-15 FEET	378
4.8E-01 FEET	4	135	6	8.0E-02 FEET	282
5.6E-01 FEET	2	139	2	1.6E-01 FEET	60
6.4E-01 FEET		141	0	2.4E-01 FEET	21
				3.2E-01 FEET	1
				4.0E-01 FEET	

Figure 8 - Sheet f

DOUBLE AMPLITUDES					DATA POINTS		
FREQUENCY DISTRIBUTION			CUMULATIVE DISTRIBUTIONS		FREQUENCY DISTRIBUTION		
BOWACC		NO OF OCC	LESS THAN	MORE THAN	BOWACC		NO OF OCC
0.	G	1	0	141	-6.0E-01	G	1
1.0E-01	G	15	1	140	-5.0E-01	G	7
2.0E-01	G	31	16	125	-4.0E-01	G	42
3.0E-01	G	21	47	94	-3.0E-01	G	80
4.0E-01	G	30	68	73	-2.0E-01	G	280
5.0E-01	G	19	98	43	-1.0E-01	G	453
6.0E-01	G	13	117	24	1.9E-15	G	283
7.0E-01	G	5	130	11	1.0E-01	G	290
8.0E-01	G	3	135	6	2.0E-01	G	73
9.0E-01	G	3	138	3	3.0E-01	G	42
1.0E+00	G		141	0	4.0E-01	G	9
					5.0E-01	G	7
					6.0E-01	G	

DOUBLE AMPLITUDES					DATA POINTS		
FREQUENCY DISTRIBUTION			CUMULATIVE DISTRIBUTIONS		FREQUENCY DISTRIBUTION		
CG ACC		NO OF OCC	LESS THAN	MORE THAN	CG ACC		NO OF OCC
7.0E-02	G	33	0	159	-3.5E-01	G	2
1.2E-01	G	28	33	126	-3.0E-01	G	3
1.7E-01	G	40	61	98	-2.5E-01	G	12
2.2E-01	G	23	101	58	-2.0E-01	G	43
2.7E-01	G	18	124	35	-1.5E-01	G	79
3.2E-01	G	7	142	17	-1.0E-01	G	266
3.7E-01	G	4	149	10	-5.0E-02	G	309
4.2E-01	G	4	153	6	2.7E-15	G	486
4.7E-01	G	2	157	2	5.0E-02	G	217
5.2E-01	G		159	0	1.0E-01	G	127
					1.5E-01	G	17
					2.0E-01	G	7
					2.5E-01	G	

DOUBLE AMPLITUDES					DATA POINTS		
FREQUENCY DISTRIBUTION			CUMULATIVE DISTRIBUTIONS		FREQUENCY DISTRIBUTION		
STRNAC		NO OF OCC	LESS THAN	MORE THAN	STRNAC		NO OF OCC
0.	G	4	0	176	-2.5E-01	G	3
5.0E-02	G	25	4	172	-2.0E-01	G	20
1.0E-01	G	59	29	147	-1.5E-01	G	55
1.5E-01	G	44	88	88	-1.0E-01	G	229
2.0E-01	G	25	132	44	-5.0E-02	G	475
2.5E-01	G	10	157	19	0.	G	498
3.0E-01	G	8	167	9	5.0E-02	G	228
3.5E-01	G	0	175	1	1.0E-01	G	41
4.0E-01	G	0	175	1	1.5E-01	G	15
4.5E-01	G	0	175	1	2.0E-01	G	2
5.0E-01	G	1	175	1	2.5E-01	G	1
5.5E-01	G		176	0	3.0E-01	G	

DOUBLE AMPLITUDES					DATA POINTS		
FREQUENCY DISTRIBUTION			CUMULATIVE DISTRIBUTIONS		FREQUENCY DISTRIBUTION		
DRAG		NO OF OCC	LESS THAN	MORE THAN	DRAG		NO OF OCC
0.	LBS	2	0	209	-1.6E+01	LBS	13
4.0E+00	LBS	17	2	207	-1.2E+01	LBS	163
8.0E+00	LBS	47	19	190	-8.0E+00	LBS	313
1.2E+01	LBS	68	66	143	-4.0E+00	LBS	349
1.6E+01	LBS	37	134	75	0.	LBS	330
2.0E+01	LBS	17	171	38	4.0E+00	LBS	242
2.4E+01	LBS	10	188	21	8.0E+00	LBS	105
2.8E+01	LBS	7	198	11	1.2E+01	LBS	25
3.2E+01	LBS	4	205	4	1.6E+01	LBS	20
3.6E+01	LBS		209	0	2.0E+01	LBS	7
					2.4E+01	LBS	

Figure 8 - Sheet g

DOUBLE AMPLITUDES				DATA POINTS	
FREQUENCY DISTRIBUTION		CUMULATIVE DISTRIBUTIONS		FREQUENCY DISTRIBUTION	
SKRTPR	NO OF OCC	LESS THAN	MORE THAN	SKRTPR	NO OF OCC
1.6E+00 LB/FT2	19	0	59	-2.0E+00 LB/FT2	3
2.0E+00 LB/FT2	18	19	40	-1.6E+00 LB/FT2	15
2.4E+00 LB/FT2	15	37	22	-1.2E+00 LB/FT2	93
2.8E+00 LB/FT2	4	52	7	-8.0E-01 LB/FT2	344
3.2E+00 LB/FT2	1	56	3	-4.0E-01 LB/FT2	314
3.6E+00 LB/FT2	2	57	2	2.0E-14 LB/FT2	459
4.0E+00 LB/FT2		59	0	4.0E-01 LB/FT2	182
				8.0E-01 LB/FT2	122
				1.2E+00 LB/FT2	26
				1.6E+00 LB/FT2	6
				2.0E+00 LB/FT2	2
				2.4E+00 LB/FT2	1
				2.8E+00 LB/FT2	

DOUBLE AMPLITUDES				DATA POINTS	
FREQUENCY DISTRIBUTION		CUMULATIVE DISTRIBUTIONS		FREQUENCY DISTRIBUTION	
CUSHPR	NO OF OCC	LESS THAN	MORE THAN	CUSHPR	NO OF OCC
1.2E+00 LB/FT2	1	0	43	-2.8E+00 LB/FT2	1
1.6E+00 LB/FT2	17	1	42	-2.4E+00 LB/FT2	3
2.0E+00 LB/FT2	9	18	25	-2.0E+00 LB/FT2	12
2.4E+00 LB/FT2	11	27	16	-1.6E+00 LB/FT2	27
2.8E+00 LB/FT2	3	38	5	-1.2E+00 LB/FT2	92
3.2E+00 LB/FT2	1	41	2	-8.0E-01 LB/FT2	141
3.6E+00 LB/FT2	1	42	1	-4.0E-01 LB/FT2	395
4.0E+00 LB/FT2		43	0	3.4E-14 LB/FT2	507
				4.0E-01 LB/FT2	322
				8.0E-01 LB/FT2	59
				1.2E+00 LB/FT2	5
				1.6E+00 LB/FT2	

Figure 8 - Sheet h

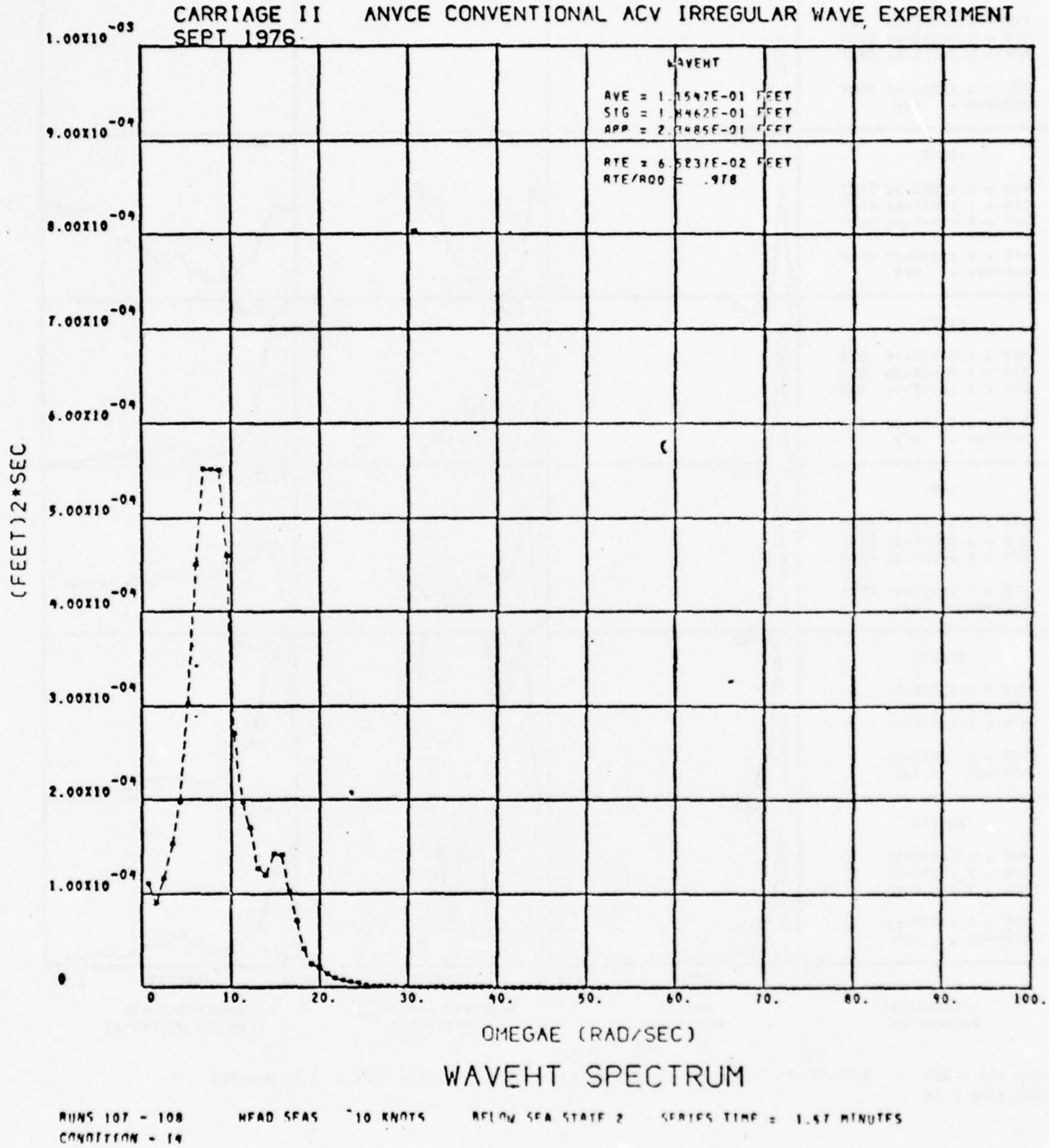
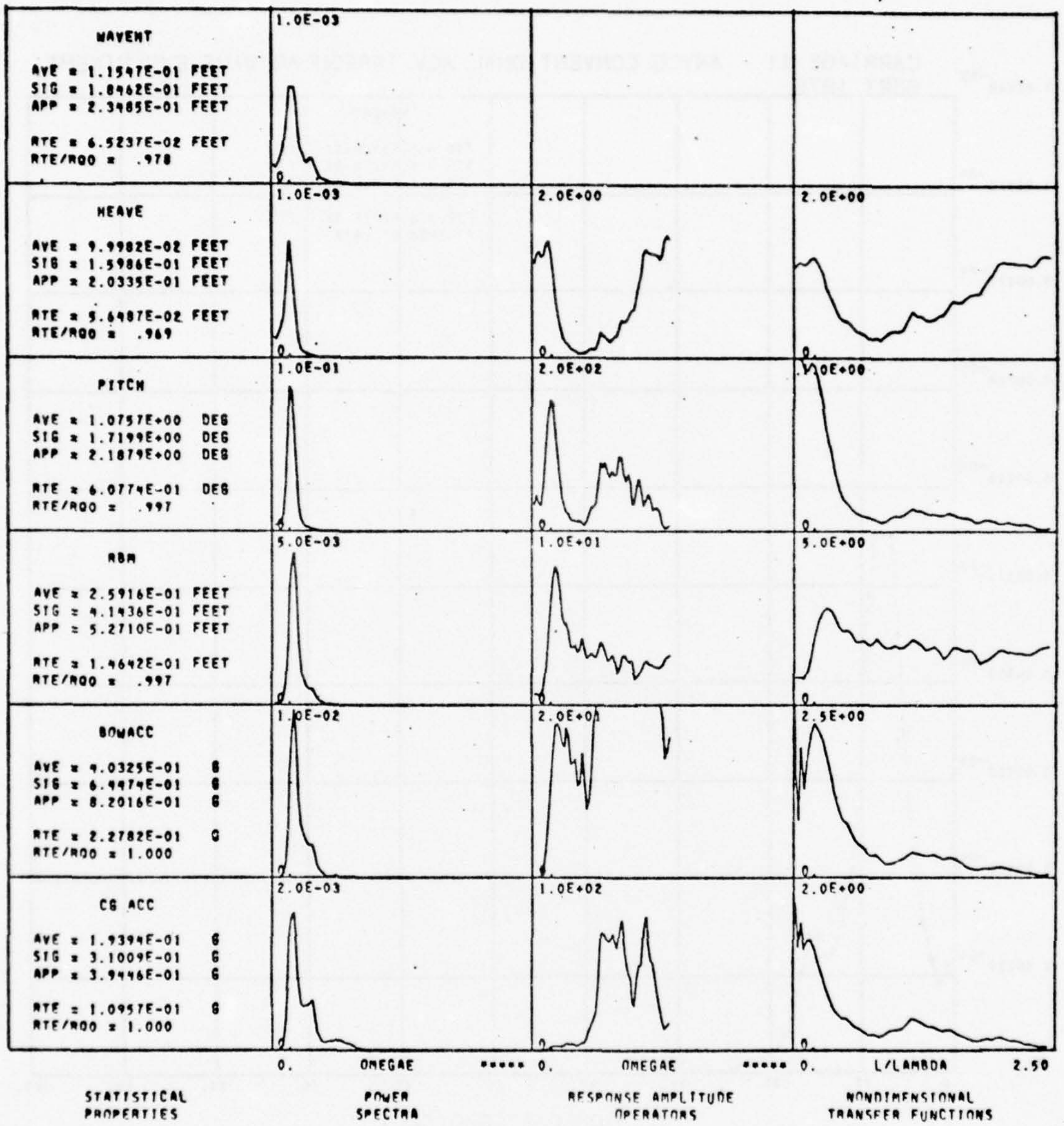


Figure 8 - Sheet i



RUNS 107 - 108 HEAD SEAS 10 KNOTS BELOW SEA STATE 2 SERIES TIME = 1.57 MINUTES
CONDITION - 14

Figure 8 - Sheet j

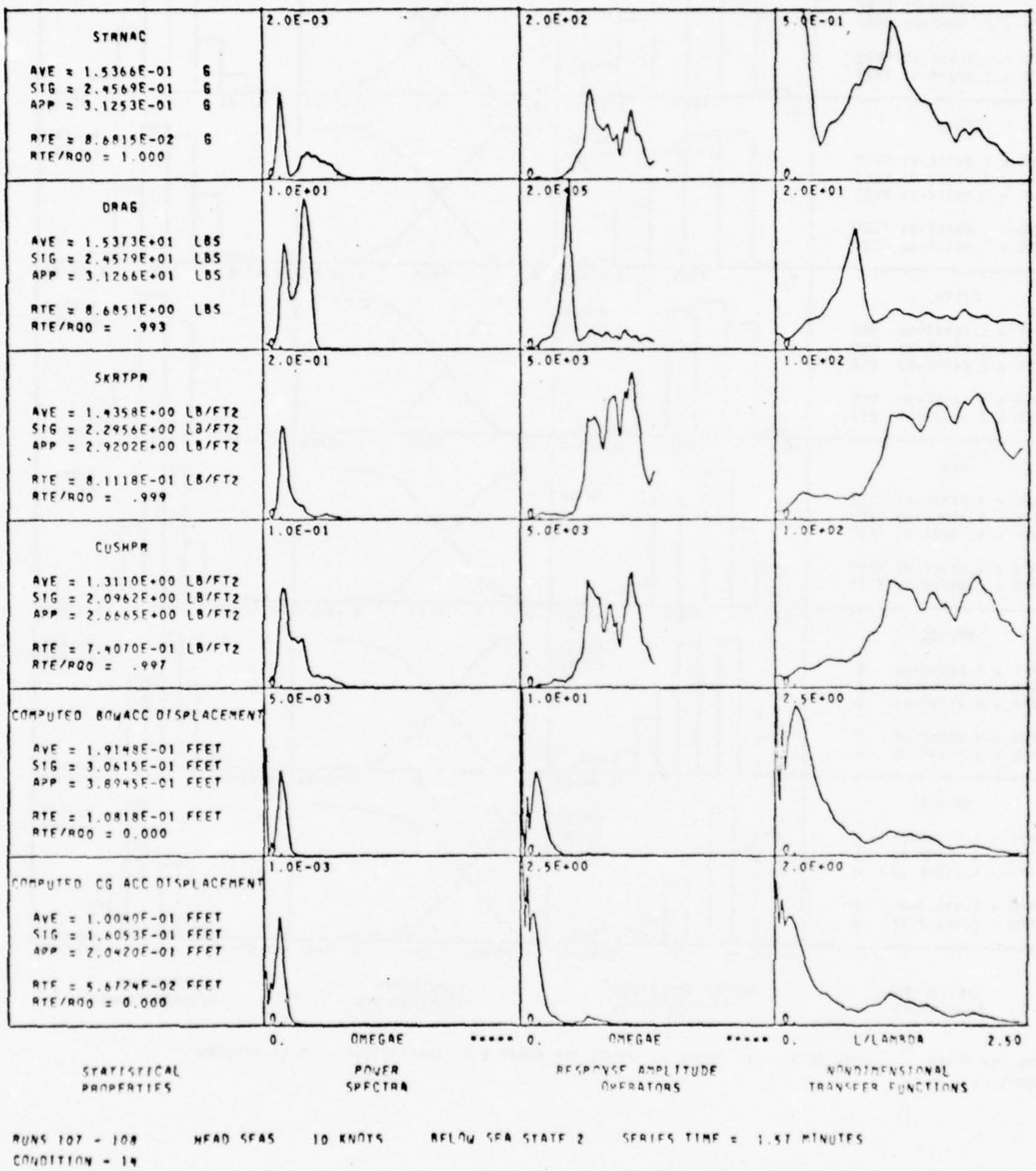


Figure 8 - Sheet k

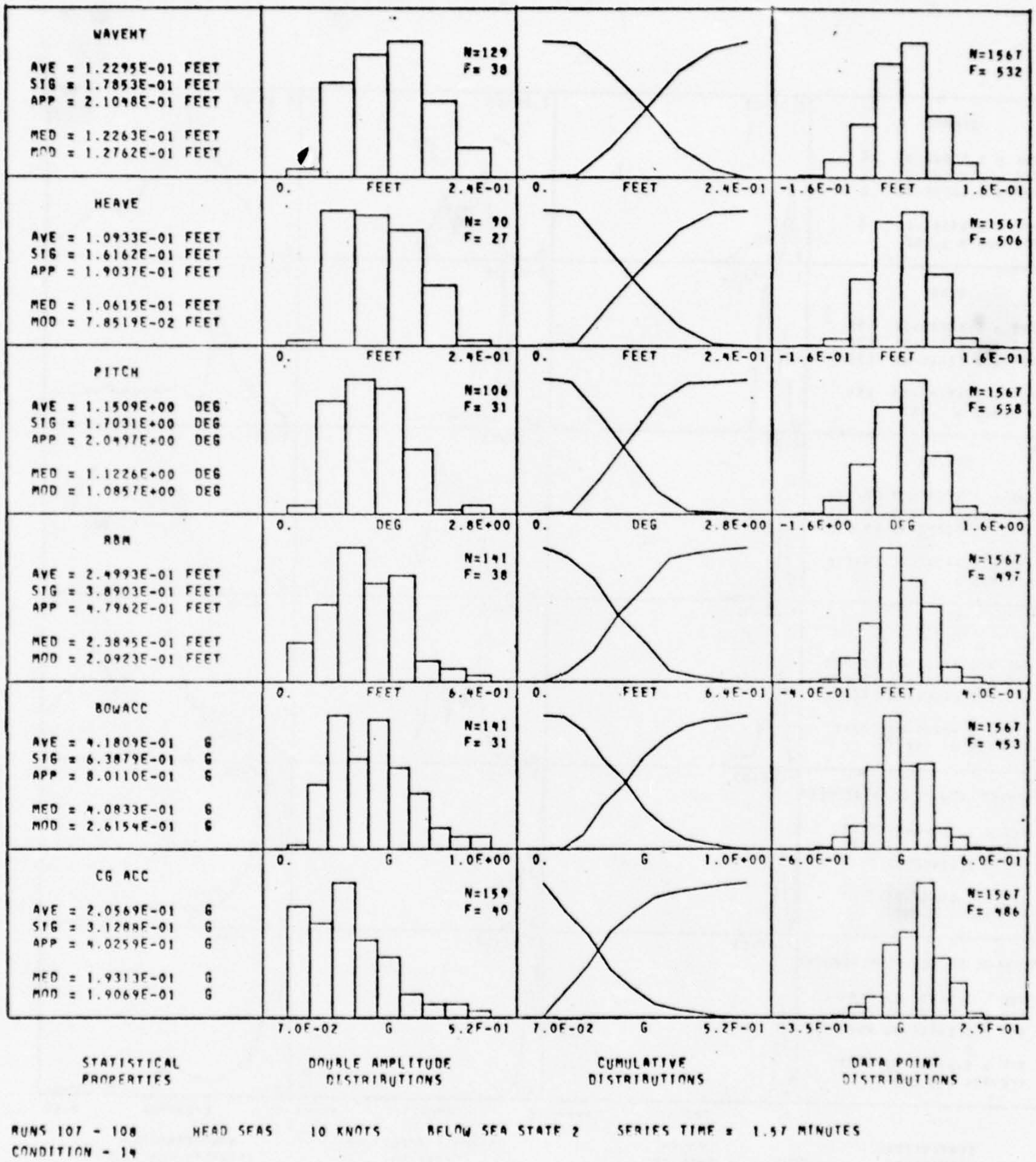


Figure 8 - Sheet 1

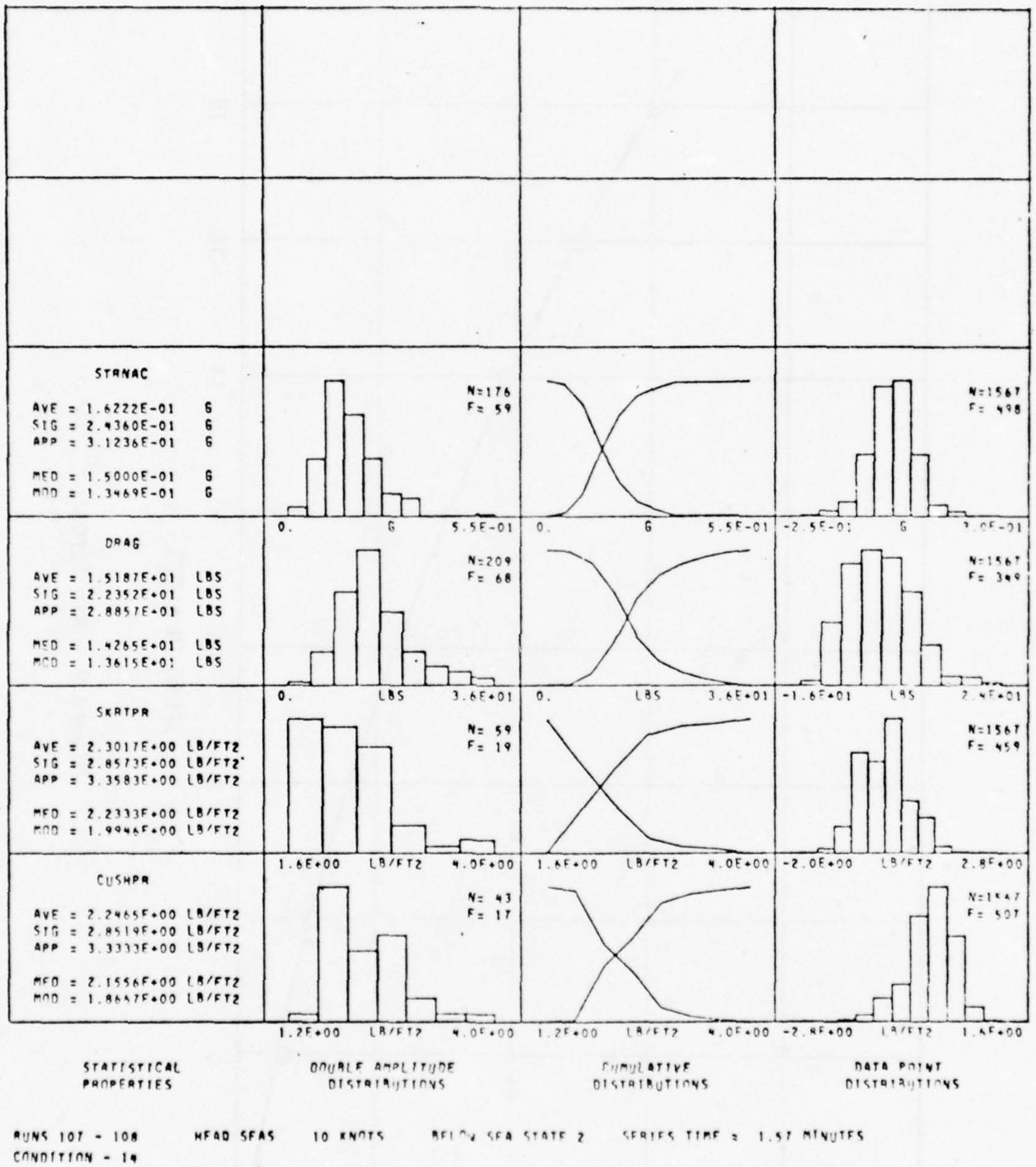


Figure 8 - Sheet m

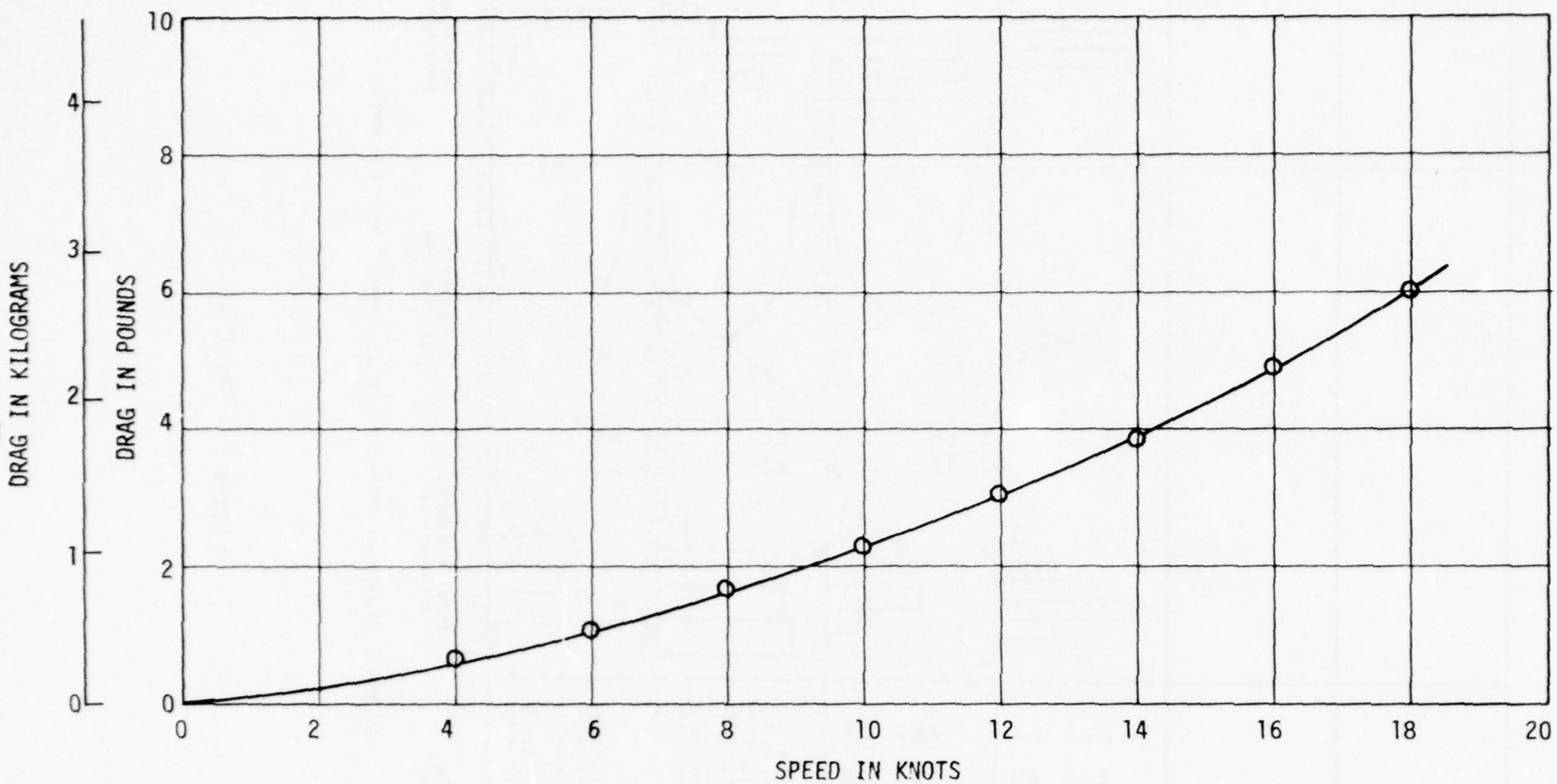


Figure 9 - Air Tares

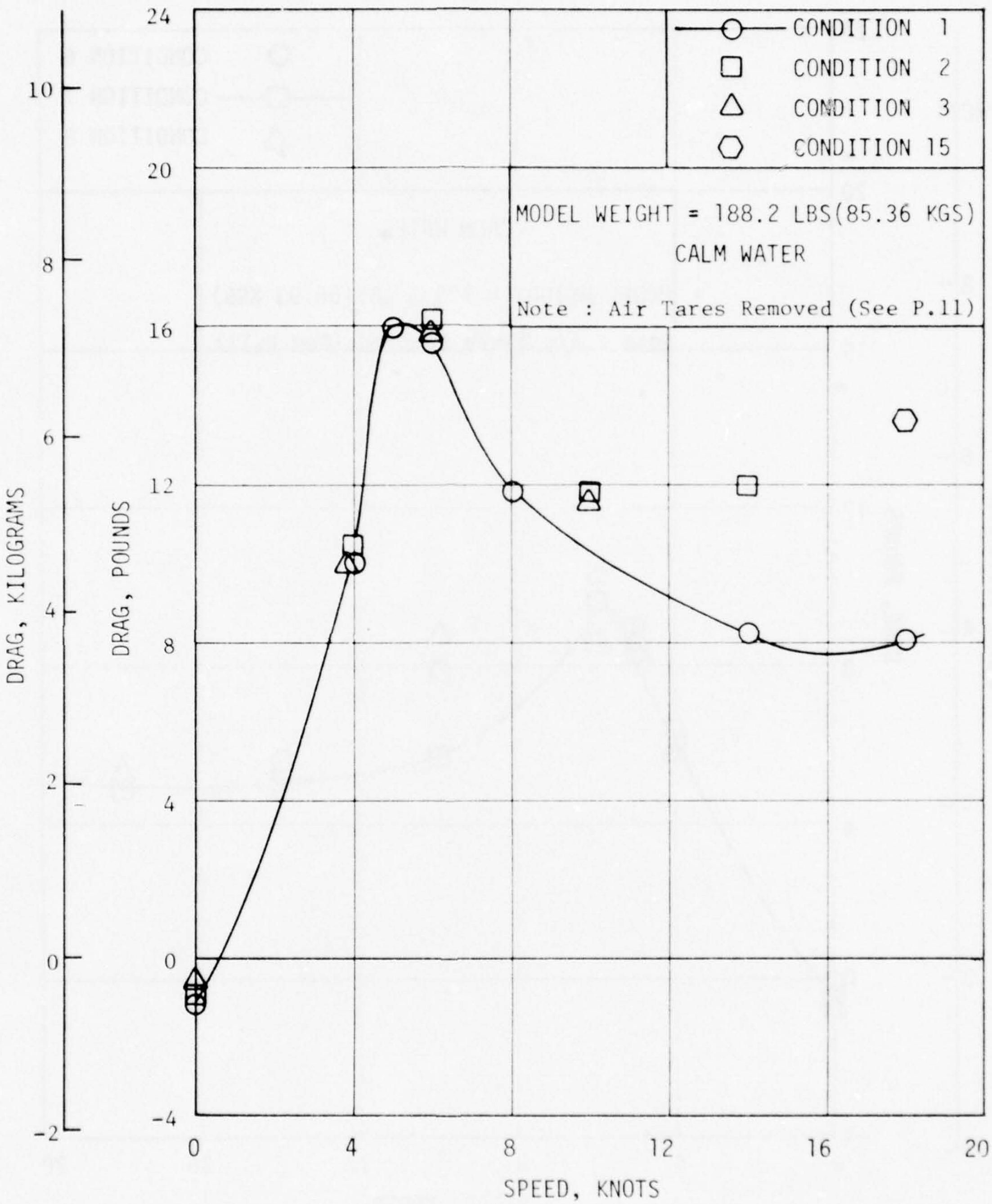


Figure 10 - Drag as a Function of Speed in Calm Water; Model Weight = 188.2 Lbs.(85.36 Kgs.)

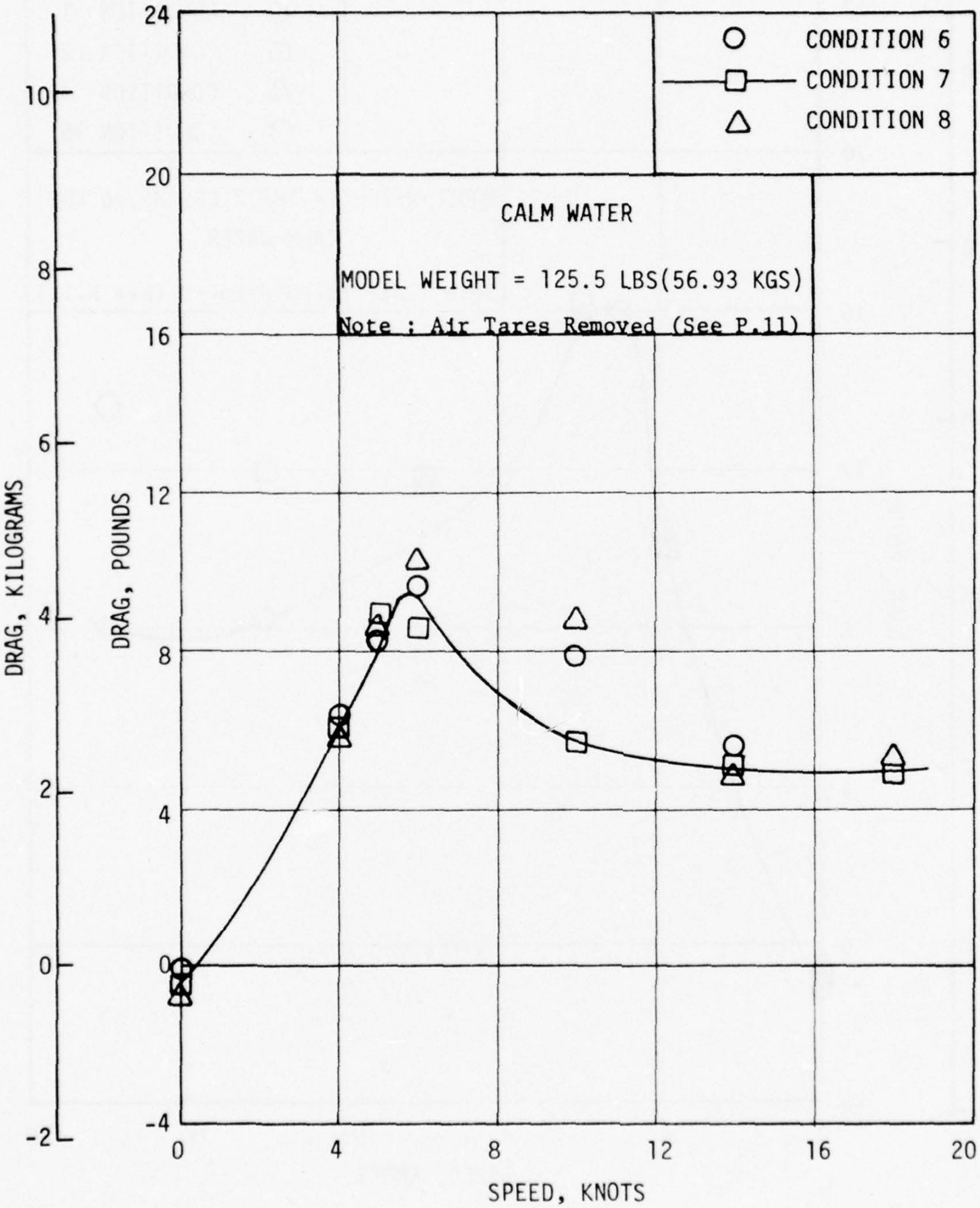


Figure 11 - Drag as a Function of Speed in Calm Water; Model Weight = 125.5 Lbs.(56.93 Kgs.)

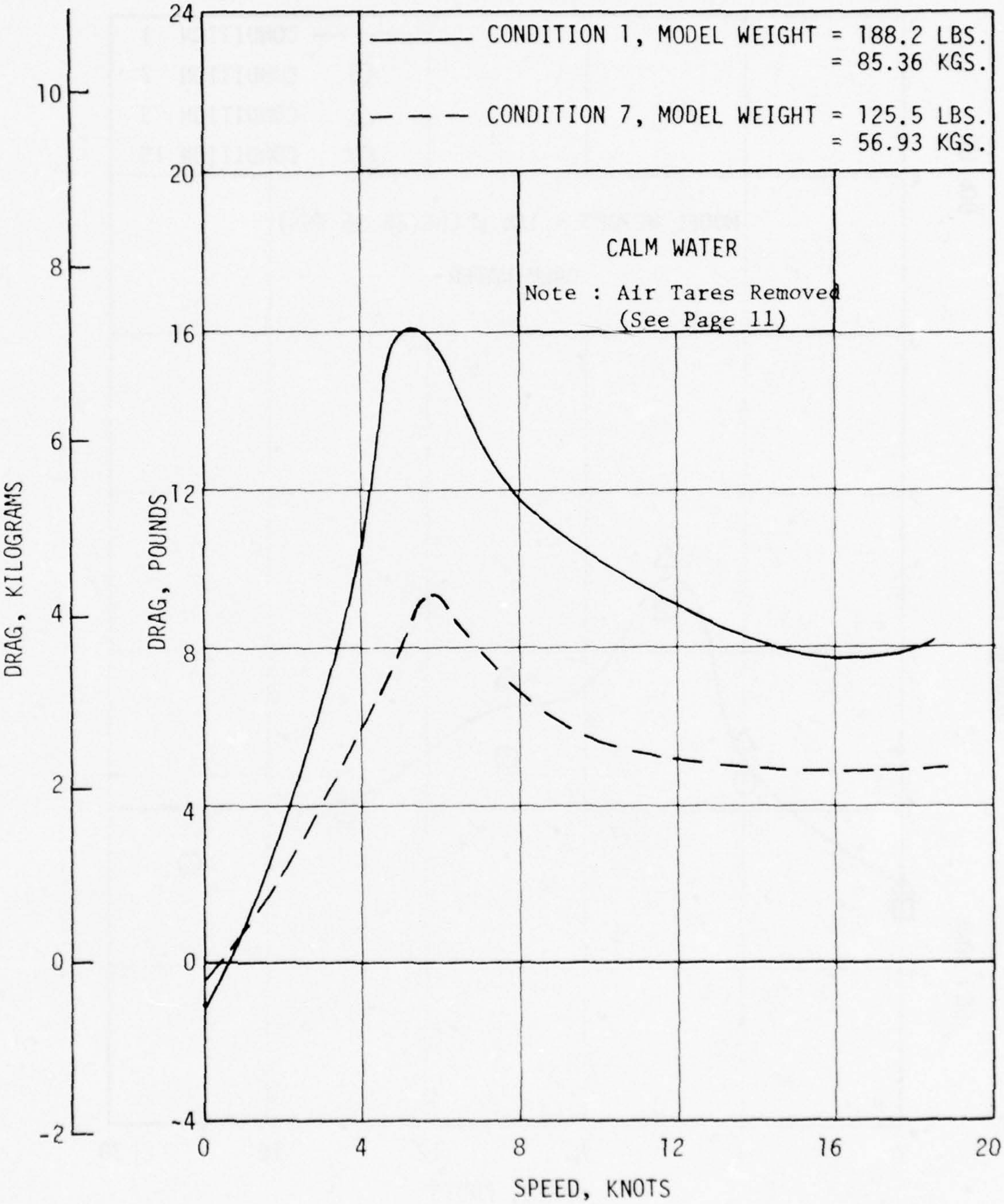


Figure 12 - Comparison of Calm Water Drag for Two Model Weights

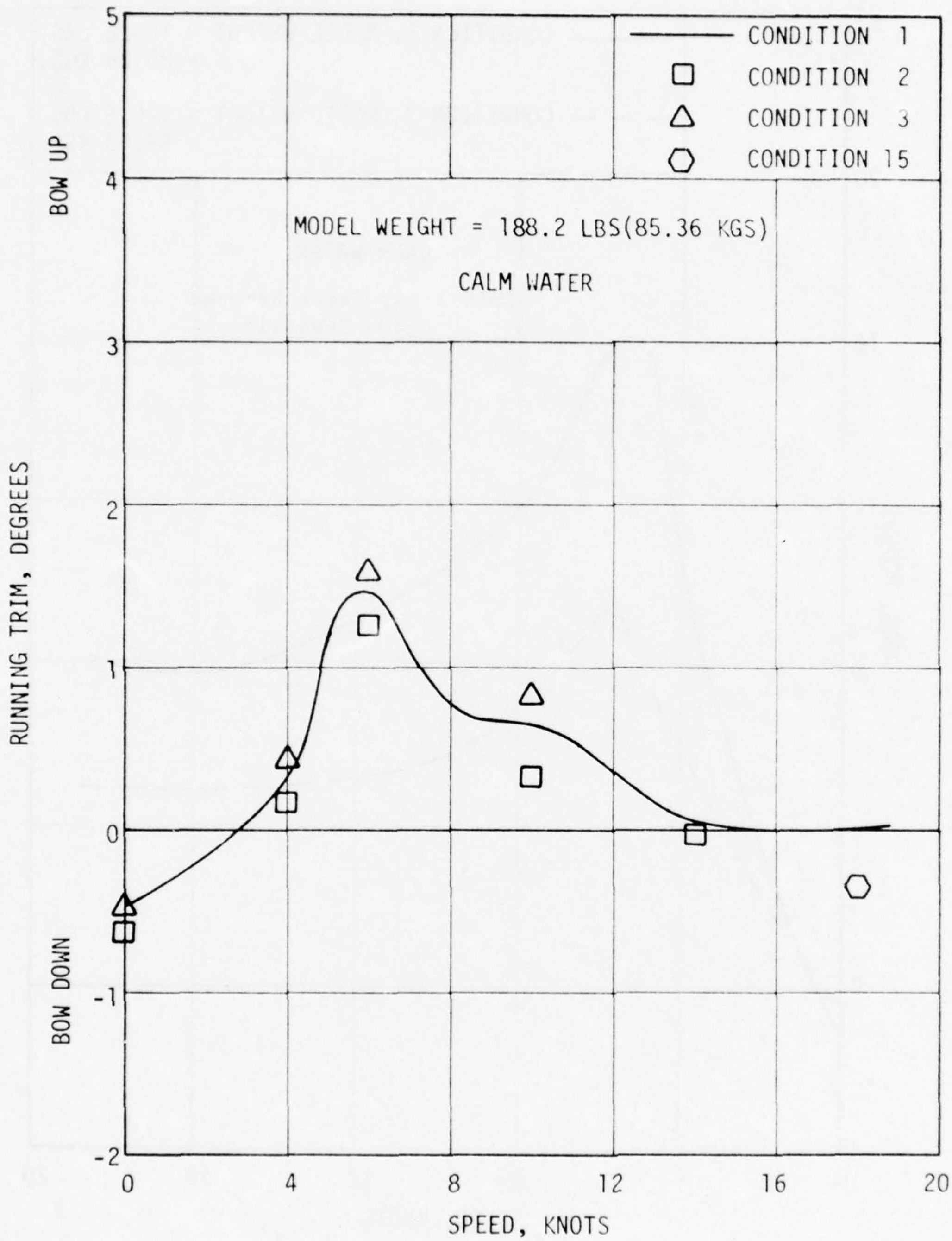


Figure 13 - Variation of Running Trim with Speed in Calm Water; Model Weight = 188.2 Lbs.(85.36 Kgs.)

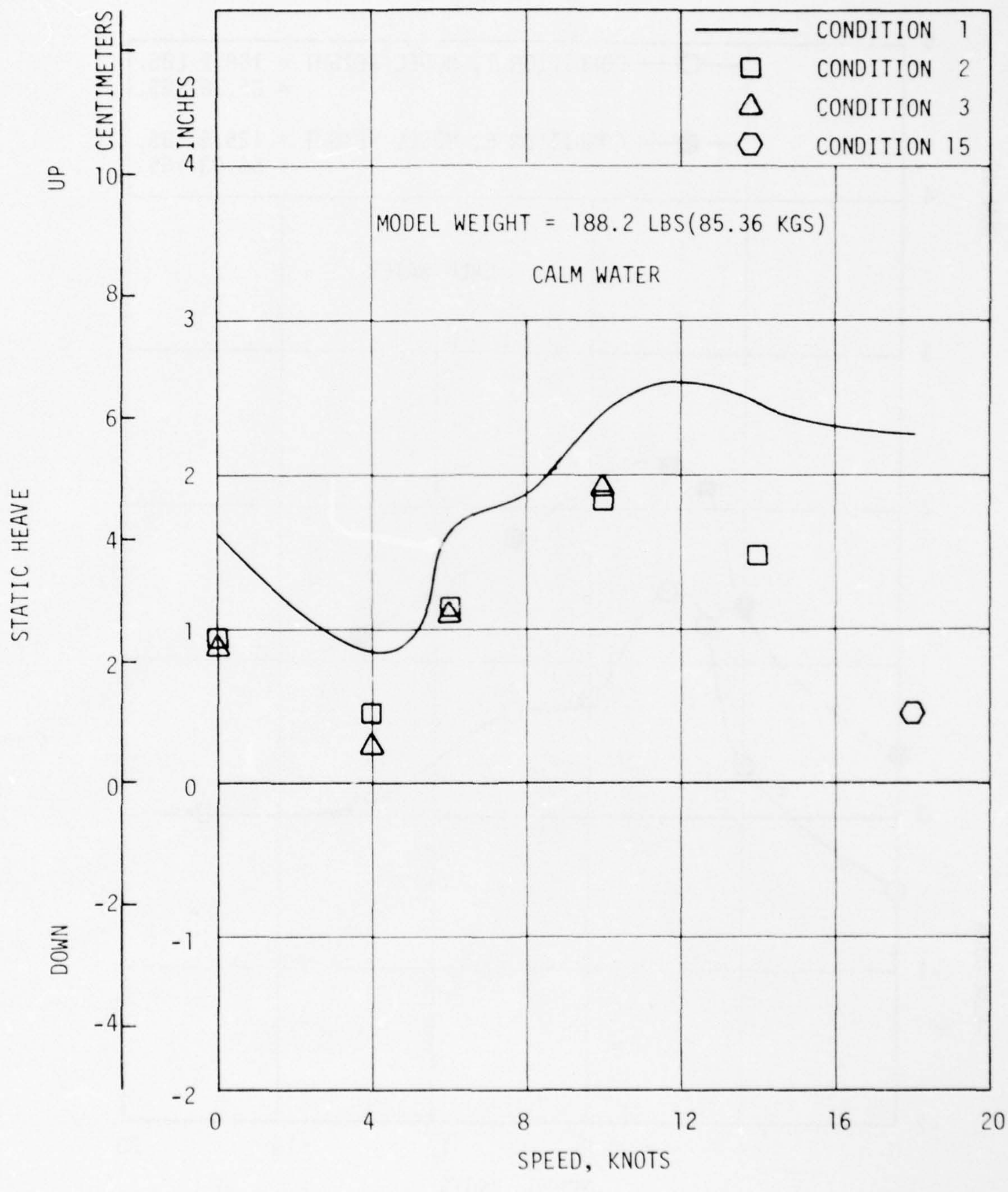


Figure 14 - Variation of Static Heave with Speed in Calm Water; Model Weight = 188.2 Lbs.(85.36 Kgs.)

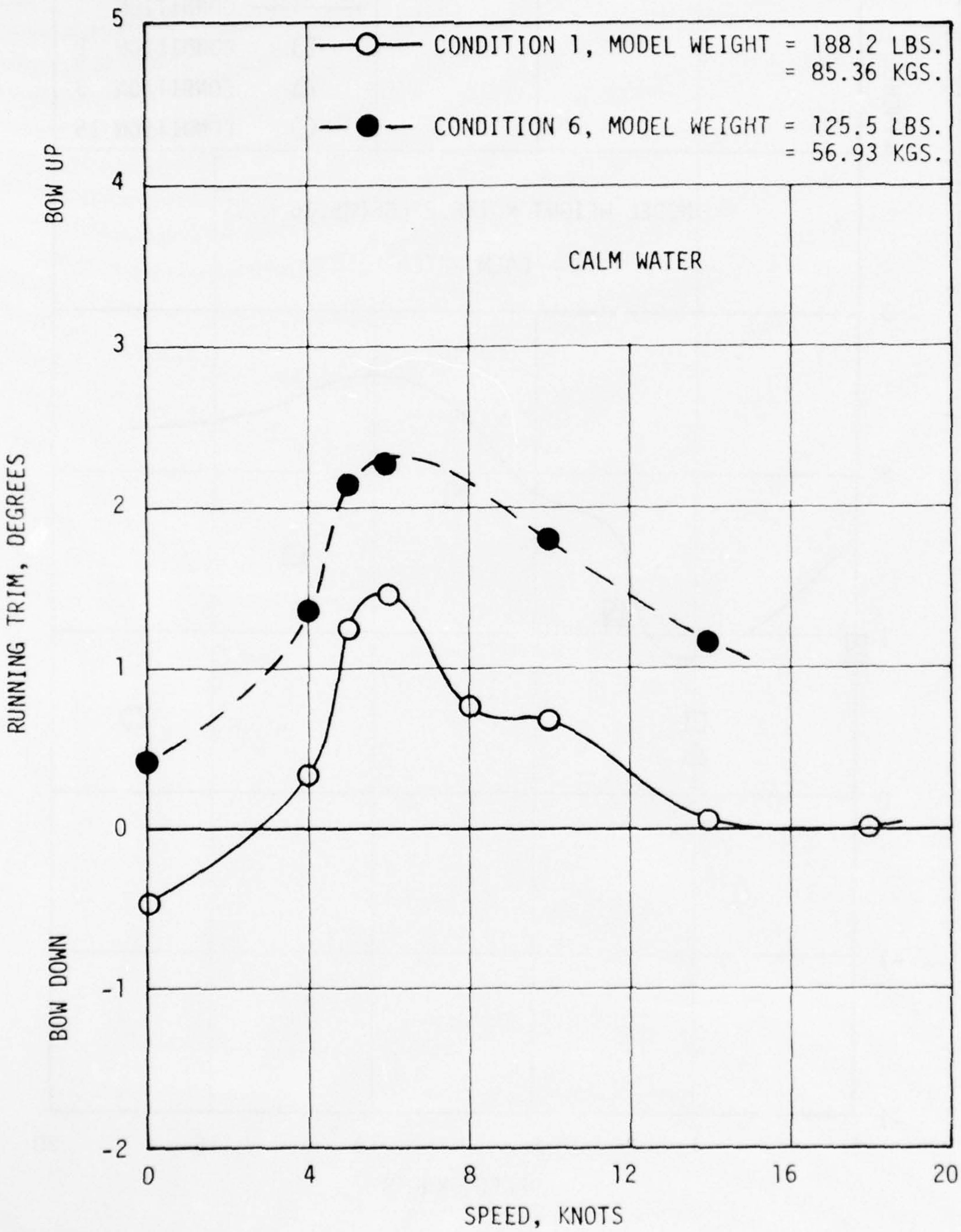


Figure 15 - Comparison of Running Trim for Two Model Weights

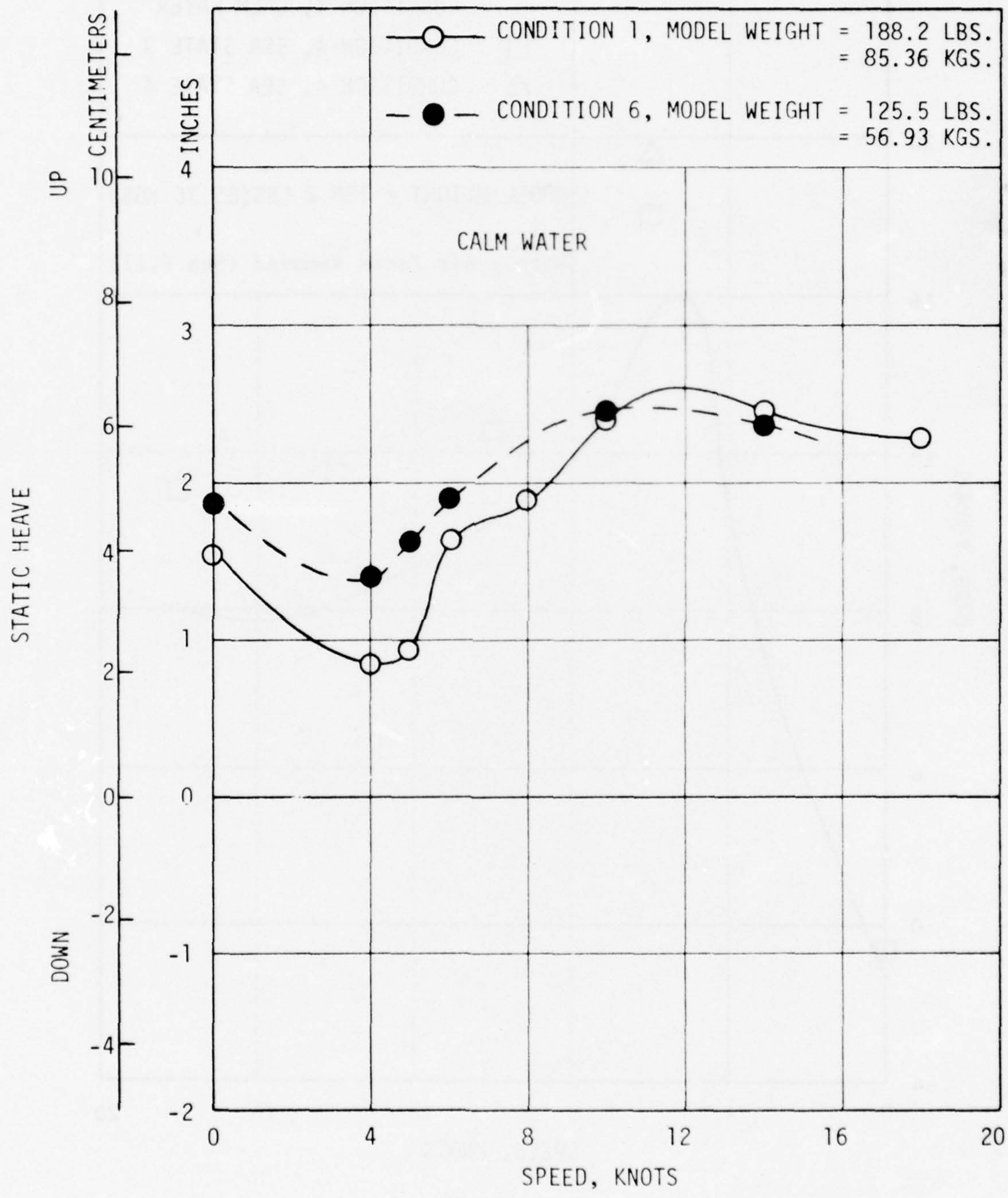


Figure 16 - Comparison of Static Heave for Two Model Weights

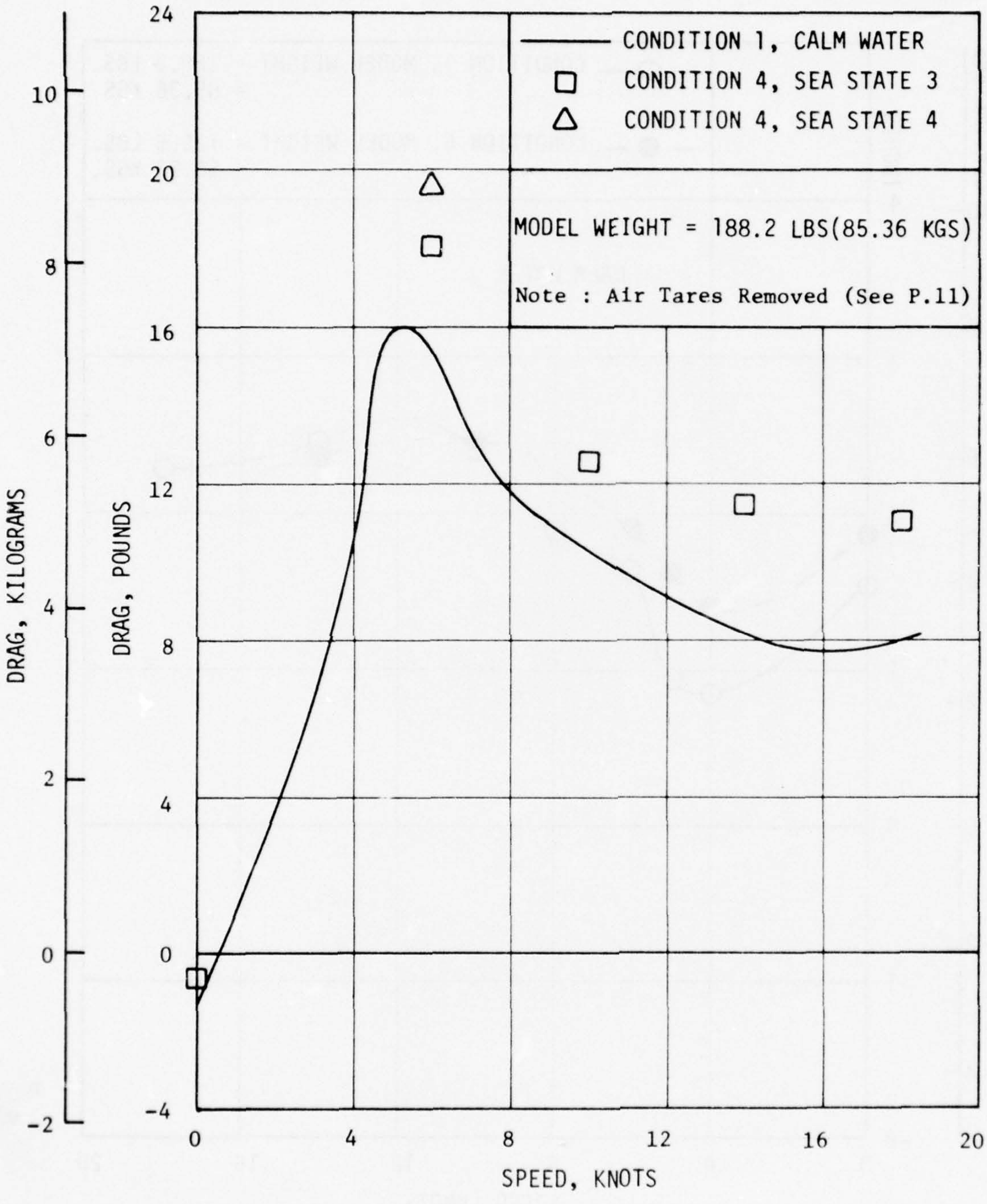


Figure 17 - Drag as a Function of Speed in Head Seas;
Model Weight = 188.2 Lbs.(85.36 Kgs.)

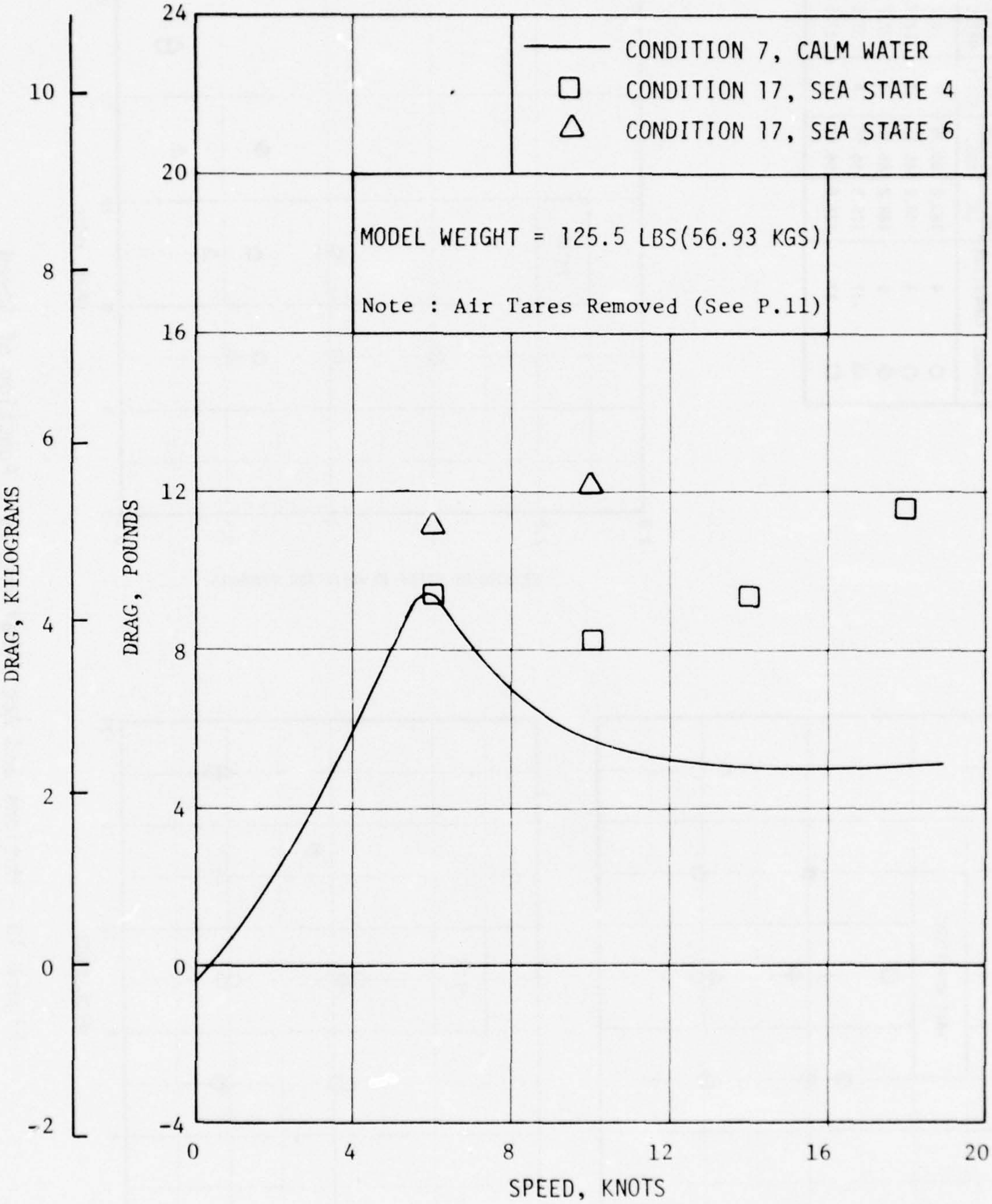
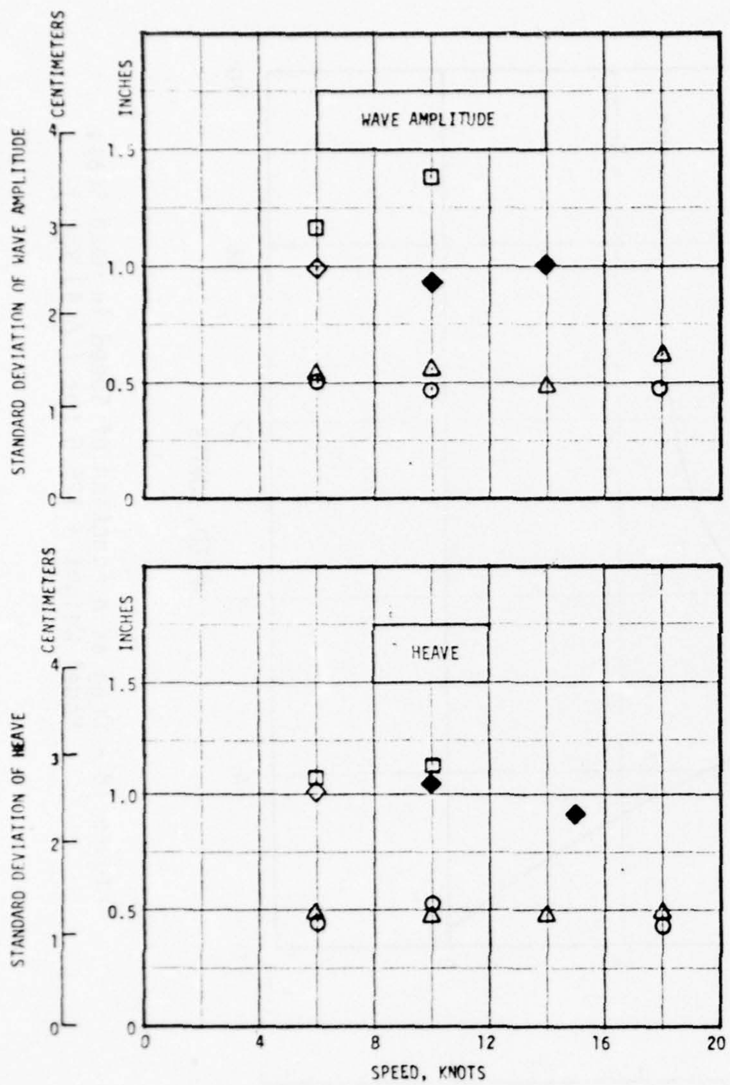


Figure 18 - Drag as a Function of Speed in Head Seas;
Model Weight = 125.5 Lbs.(56.93 Kgs.)



SYMBOL	CONDITION	MODEL WEIGHT LBS.	MODEL WEIGHT KGS.	SEA STATE	SCALE RATIO
○	4	188.2	85.36	3	22.7
◇	4	188.2	85.36	4	22.7
◆	5	188.2	85.36	4	22.7
△	17	125.5	56.93	4	37.5
□	17	125.5	56.93	6	37.5

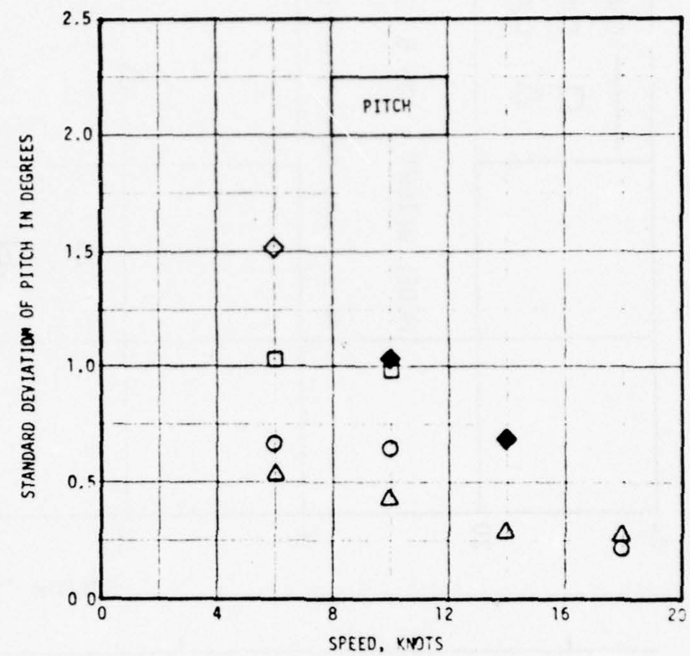
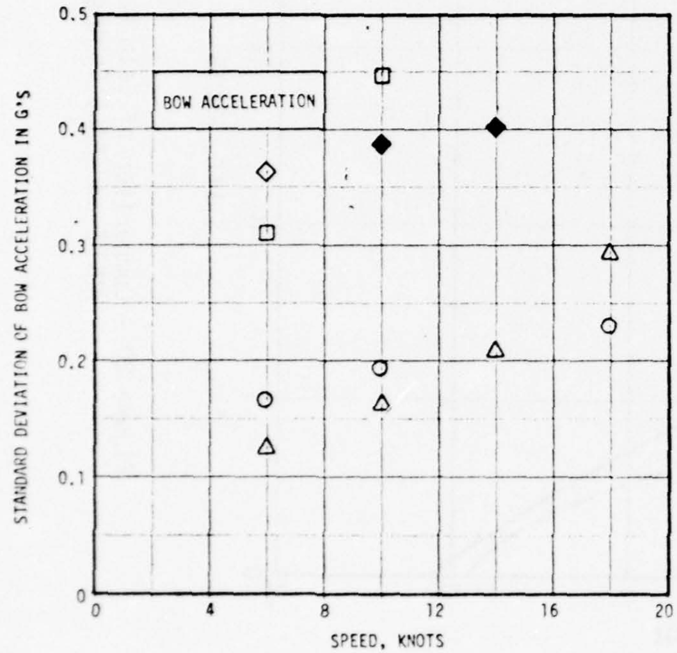
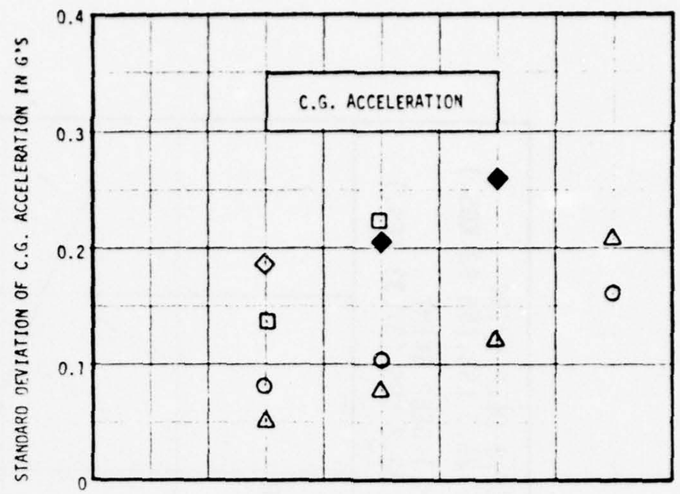


Figure 19 - Motions and Accelerations as a Function of Speed for Various Sea States and Model Conditions

SYMBOL	CONDITION	MODEL WEIGHT LBS.	MODEL WEIGHT KGS.	SEA STATE	SCALE RATIO
○	4	188.2	85.36	3	22.7
◇	4	188.2	85.36	4	22.7
◆	5	188.2	85.36	4	22.7
△	17	125.5	56.93	4	37.5
□	17	125.5	56.93	6	37.5





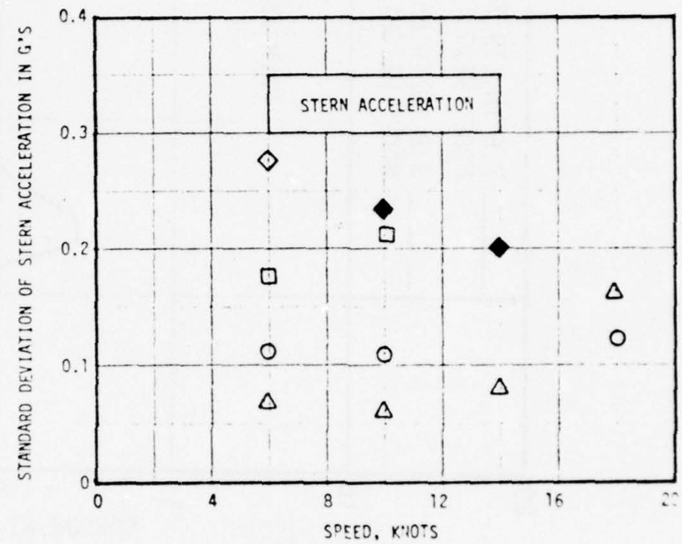


Figure 19 - "Continued"

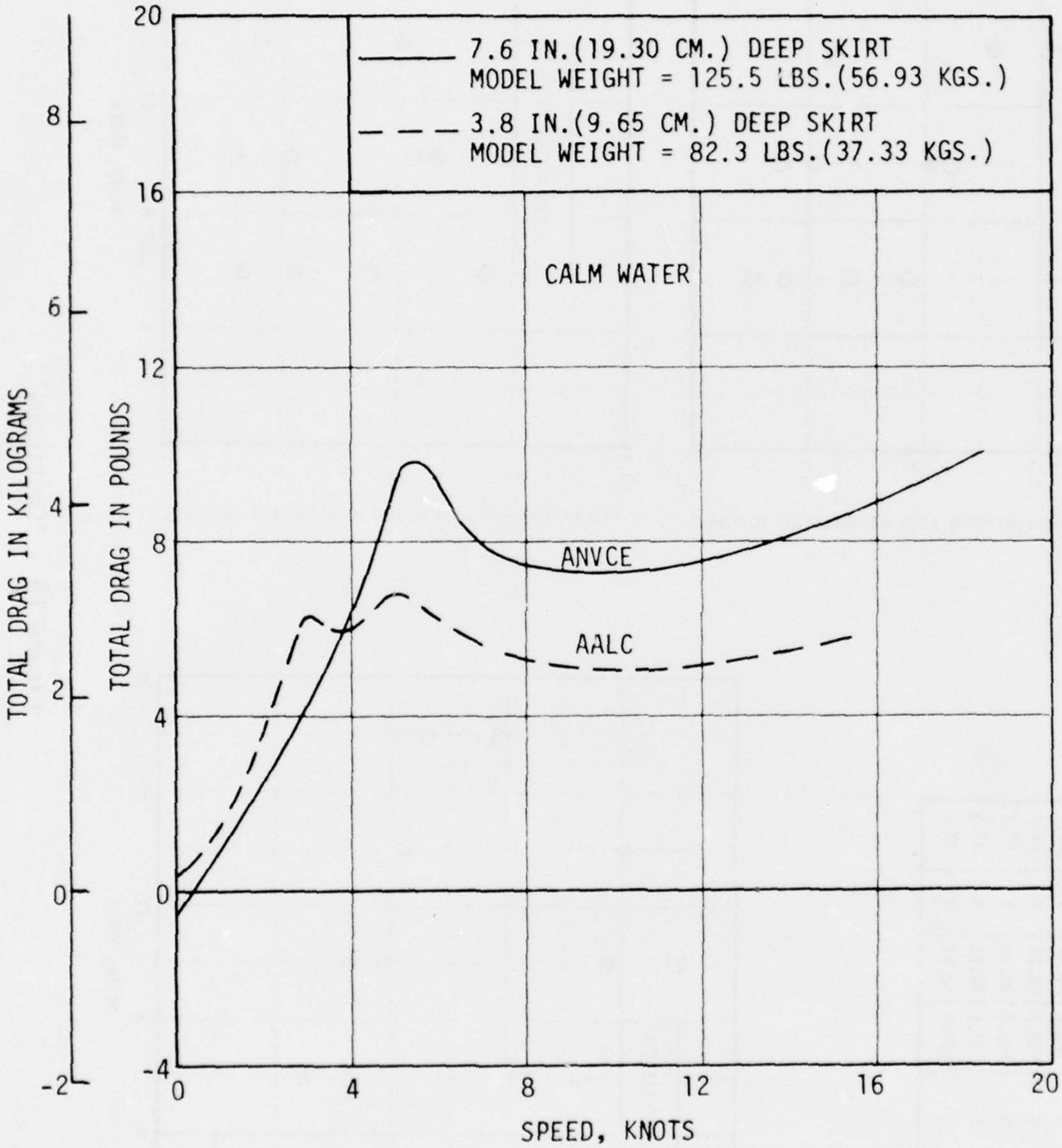


Figure 20 - Comparison of Calm Water Drag for ANVCE and AALC Configurations

TABLE 1

PRINCIPAL MODEL CHARACTERISTICS

	UNITS	
	ENGLISH	METRIC
LENGTH, OVERALL*	6.6 FT	2.00 M
BEAM, OVERALL*	3.1 FT	0.94 M
WEIGHT	188.2 LBS	85.36 KGS
WEIGHT	125.5 LBS	56.93 KGS
CUSHION AREA @ 188.2 LBS (85.36 KGS)	17.6 FT^2	1.64 M^2
CUSHION AREA @ 125.5 LBS (56.93 KGS)	16.9 FT^2	1.57 M^2
CUSHION LENGTH @ 125.5 LBS (56.93 KGS)	6.0 FT	1.82 M
LONGITUDINAL LOCATION OF C.G. FORWARD OF TRANSOM	2.9 FT	0.89 M
PITCH MOMENT OF INERTIA @ 188.2 LBS (85.36 KGS).	15.4 $FT\text{-}LB\text{-}SEC^2$	20.88 $KG\text{-}M^2$
PITCH MOMENT OF INERTIA @ 125.5 LBS (56.93 KGS).	11.3 $FT\text{-}LB\text{-}SEC^2$	15.32 $KG\text{-}M^2$

* WITH SKIRT DEFLATED

TABLE 2

SCHEDULE OF TEST CONDITIONS

RUN NO.	MODEL WEIGHT, LBS (KILOGRAMS)	FANS USED	FAN RPM	SPEED, KTS	WAVE CONDITION	COMMENTS
1	188.2 (85.4)	3,4,5,6,8,9	22,500	0	CALM	
2				4		
3				6		
4				10		
5				14		
6						BAD RUN
7				18		
8				5		
9				8		
10		3,4,8,9		0		
11				4		
12				6		
13				10		
14				14		
15		3,4,5,8,9	20,250	0		
16				4		
17				6		
18				10		

TABLE 2

SCHEDULE OF TEST CONDITIONS (CONTINUED)

RUN NO.	MODEL WEIGHT, LBS (KILOGRAMS)	FANS USED	FAN RPM	SPEED, KTS	WAVE CONDITION	COMMENTS
19				--		WAVEMAKER CALIBRATION
20				--		WAVEMAKER CALIBRATION
21	188.2 (85.4)	3,4,5,6,8,9	22,500	6	SEA STATE 3	SR = 22.7
22				6		
23				10		
24				10		
25				10		
26				14		
27				18		
28				18		
29				18		
30				18		
31				18		
32				0		
33				0	↓	↓
34				6	SEA STATE 4	SR = 22.7
35	↓	↓	↓	6	↓	↓

TABLE 2

SCHEDULE OF TEST CONDITIONS (CONTINUED)

RUN NO.	MODEL WEIGHT, LBS (KILOGRAMS)	FANS USED	FAN RPM	SPEED, KTS	WAVE CONDITION	COMMENTS
36	188.2 (85.4)	3,4,5,6,8,9	22,500	10	SEA STATE 4	BAD RUN SR = 22.7
37		3,4,5,8,9,10		10		
38				10		
39				10		
40				14		
41				14		
42				14		
43				0		
44				0		
45				10	SEA STATE 6	BAD RUN SR = 22.7
46	125.5 (56.9)	3,4,5,8,9	18,000	0	CALM	
47				4		
48				6		
49				10		
50				0		
51				5		
52				14		
53				0		
54				18		

TABLE 2

SCHEDULE OF TEST CONDITIONS (CONTINUED)

RUN NO.	MODEL WEIGHT, LBS (KILOGRAMS)	FANS USED	FAN RPM	SPEED, KTS	WAVE CONDITION	COMMENTS
55	125.5 (56.9)	1,2,3,4,5,7,8,9,10	20,250	0	CALM	BAD RUN
56	↓	↓	↓	0	↓	
57				4		
58				0		
59				4		
60				6		
61				10		
62				5		
63				14		
64		↓	↓	18		
65		3,4,5,8,9,10	20,500	0		
66		↓	↓	4		
67				6		
68				10		
69				5		
70				14		
71	↓	↓	↓	18	↓	

TABLE 2

SCHEDULE OF TEST CONDITIONS (CONTINUED)

RUN NO.	MODEL WEIGHT, LBS (KILOGRAMS)	FANS USED	FAN RPM	SPEED, KTS	WAVE CONDITION	COMMENTS
72	125.5 (56.9)	3,4,5,8,9,10	22,500	0	CALM	AIR TARES
73				2		
74				4		
75				6		
76				8		
77				0		
78				2		
79				4		
80				6		
81				8		
82				10		
83				12		
84				6		
85				14		
86				8		
87				16		
88				18		
89				4		
90				10		
91				12		

TABLE 2

SCHEDULE OF TEST CONDITIONS (CONTINUED)

RUN NO.	MODEL WEIGHT, LBS (KILOGRAMS)	FANS USED	FAN RPM	SPEED, KTS	WAVE CONDITION	COMMENTS
92	188.2 (85.4)	3,4,5,8,9,10	20,500	18	SEA STATE 4	BAD RUN SR = 22.7
93				18	CALM	
94				6	SEA STATE 3	SR = 32.8
95				6		
96				6		
97		3,4,5,8,9	20,250	10		
98				10		
99				10		
100		3,4,8,9	22,500	18		MODEL BOW
101				18		DOWN & DEEP
102				18	CALM	
103		2,3,4,5,7,8,9	20,250	18		
104	125.5 (56.9)	1,3,5,7,8,10		18		
105		3,4,5,8,9		6	SEA STATE 4	SR = 37.5
106				6		
107				10		
108				10		
109				14		
110				14		

TABLE 2

SCHEDULE OF TEST CONDITIONS (CONTINUED)

RUN NO.	MODEL WEIGHT, LBS (KILOGRAMS)	FANS USED	FAN RPM	SPEED, KTS	WAVE CONDITION	COMMENTS
111	125.5 (56.9)	3,4,5,8,9	20,250	14	SEA STATE 4	SR = 37.5
112	↓	↓	↓	18	↓	↓
113	↓	↓	↓	18	↓	↓
114	↓	↓	↓	18	↓	↓
115	↓	↓	↓	18	↓	↓
116	↓	↓	↓	18	↓	↓
117	↓	↓	↓	6	SEA STATE 6	SR = 37.5
118	↓	↓	↓	6	↓	↓
119	↓	↓	↓	10	↓	↓
120	↓	↓	↓	10	↓	↓

TABLE 3

MODEL CONDITIONS FOR EXPERIMENTS

CONDITION	RUN NUMBERS	MODEL WEIGHT		FANS USED	FAN RPM
		LBS	KGS		
1	1 - 9	188.2	85.36	3,4,5,6,8,9	22,500
2	10 - 14	188.2	85.36	3,4,8,9	22,500
3	15 - 18	188.2	85.36	3,4,5,8,9	20,250
4	19 - 35	188.2	85.36	3,4,5,6,8,9	22,500
5	37 - 45	188.2	85.36	3,4,5,8,9,10	22,500
6	46 - 54	125.5	56.93	3,4,5,8,9	18,000
7	55 - 64	125.5	56.93	1,2,3,4,5,7,8,9,10	20,250
8	65 - 71	125.5	56.93	3,4,5,8,9,10	20,500
9	72 - 76	125.5	56.93	3,4,5,8,9,10	22,500
10	77 - 91	125.5	56.93	3,4,5,8,9,10	22,500
11	92	188.2	85.36	3,4,5,8,9,10	22,500
12	93 - 96	188.2	85.36	3,4,5,8,9,10	20,500
13	97 - 99	188.2	85.36	3,4,5,8,9	20,250
14	100 - 102	188.2	85.36	3,4,8,9	22,500
15	103	188.2	85.36	2,3,4,5,7,8,9	20,250
16	104	125.5	56.93	1,3,5,7,8,10	20,250
17	105 - 120	125.5	56.93	3,4,5,8,9	20,250

TABLE 4

INSTRUMENTATION AND COMPUTER NOTES

1. The zero for heave was taken with the weather deck edge at the longitudinal position of the CG 10.0 inches above the water surface.

2. On Interdata computer printouts, relative bow motion is too large by a factor of 5 for Runs 1 - 4.

3. Run 6 is bad because of unsteady carriage speed.

4. Fans out half way through Run 45.

5. For Runs 53 and 54, 1.7 pounds should be subtracted from mean drag on the Interdata computer printouts and 0.22 inches should be subtracted from mean heave.

6. For Runs 46-52, 1.7 inches should be added to mean heave on the Interdata computer printouts and 0.4 degrees should be added to mean pitch. In addition, the cushion pressure values on the Interdata printout are not correct.

7. Fans out during Runs 55 and 57.

8. Lift in bow region lost during Run 100.

9. Air tares conducted with fans 3, 4, 5, 8, 9, 10 operating at 22,500 rpm.

10. Runs 19 and 20 are wavemaker calibrations.

11. Model plow-in occurred during Runs 101 and 102.

)

TABLE 5

SUMMARY OF MODEL RESPONSES IN SEA STATE 3* AT A WEIGHT OF 188.2 POUNDS (85.36 KILOGRAMS) FOR VARIOUS MODEL SPEEDS

FANS : 3,4,5,6,8,9 RPM = 22,500

	UNITS	SPEED IN KNOTS			
		6	10	14	18
WAVE AMPLITUDE	INCHES (CM)	0.49 (1.24)	0.47 (1.18)	0.48 (1.22)	0.48 (1.22)
HEAVE	INCHES (CM)	0.46 (1.16)	0.54 (1.38)	0.43 (1.10)	0.45 (1.15)
PITCH	DEGREES	0.64	0.60	0.32	0.23
BOW ACCELERATION	G'S	0.160	0.191	0.200	0.230
C.G. ACCELERATION	G'S	0.081	0.102	0.124	0.165
STERN ACCELERATION	G'S	0.108	0.109	0.098	0.127
MEAN DRAG**	POUNDS (KILOGRAMS)	18.19 (8.25)	12.65 (5.74)	11.59 (5.26)	11.15 (5.06)
SKIRT PRESSURE	PSI (NEWTON/M^2)	0.0065 (44.9)	0.0079 (54.5)	0.0087 (60.0)	0.0113 (77.9)
CUSHION PRESSURE	PSI (NEWTON/M^2)	0.0063 (43.4)	0.0078 (53.8)	0.0094 (64.8)	0.0123 (84.8)

* BASED ON SCALE RATIO OF 22.7

** ALL VALUES STANDARD DEVIATION EXCEPT DRAG

TABLE 6

SUMMARY OF MODEL RESPONSES IN SEA STATE 4* AT A WEIGHT OF 188.2 POUNDS (85.36 KILOGRAMS) AND ONE MODEL SPEED

FANS : 3,4,5,6,8,9 RPM = 22,500

	UNITS	SPEED IN KNOTS
		6
WAVE AMPLITUDE	INCHES (CM)	0.99 (2.50)
HEAVE	INCHES (CM)	1.01 (2.57)
PITCH	DEGREES	1.52
BOW ACCELERATION	G'S	0.365
C.G. ACCELERATION	G'S	0.194
STERN ACCELERATION	G'S	0.280
MEAN DRAG**	POUNDS (KILOGRAMS)	19.64 (8.91)
SKIRT PRESSURE	PSI (NEWTON/M^2)	0.0141 (97.2)
CUSHION PRESSURE	PSI (NEWTON/M^2)	0.0158 (108.9)

* BASED ON SCALE RATIO OF 22.7

** ALL VALUES STANDARD DEVIATION EXCEPT DRAG

TABLE 7

SUMMARY OF MODEL RESPONSES IN SEA STATE 4* AT A WEIGHT OF 188.2 POUNDS (85.36 KILOGRAMS) FOR VARIOUS MODEL SPEEDS

FANS : 3,4,5,8,9,10   RPM = 22,500

	UNITS	SPEED IN KNOTS	
		10	14
WAVE AMPLITUDE	INCHES (CM)	0.94 (2.39)	1.01 (2.58)
HEAVE	INCHES (CM)	1.06 (2.69)	0.95 (2.42)
PITCH	DEGREES	1.24	0.69
BOW ACCELERATION	G'S	0.389	0.400
C.G. ACCELERATION	G'S	0.212	0.261
STERN ACCELERATION	G'S	0.241	0.207
MEAN DRAG**	POUNDS (KILOGRAMS)	15.79 (7.16)	15.49 (7.03)
SKIRT PRESSURE	PSI (NEWTON/M^2)	0.0143 (98.6)	0.0173 (119.3)
CUSHION PRESSURE	PSI (NEWTON/M^2)	0.0164 (113.1	0.0171 (117.9)

* BASED ON SCALE RATIO OF 22.7

** ALL VALUES STANDARD DEVIATION EXCEPT DRAG

TABLE 8

SUMMARY OF MODEL RESPONSES IN SEA STATE 4* AT A WEIGHT OF 125.5 POUNDS (56.93 KILOGRAMS) FOR VARIOUS MODEL SPEEDS

FANS : 3,4,5,8,9 RPM = 20,250

	UNITS	SPEED IN KNOTS			
		6	10	14	18
WAVE AMPLITUDE	INCHES (CM)	0.52 (1.33)	0.56 (1.43)	0.51 (1.29)	0.62 (1.57)
HEAVE	INCHES (CM)	0.49 (1.24)	0.50 (1.26)	0.48 (1.22)	0.48 (1.22)
PITCH	DEGREES	0.54	0.43	0.30	0.27
BOW ACCELERATION	G'S	0.128	0.160	0.211	0.296
C.G. ACCELERATION	G'S	0.055	0.078	0.126	0.210
STERN ACCELERATION	G'S	0.069	0.063	0.084	0.166
MEAN DRAG**	POUNDS (KILOGRAMS)	9.41 (4.27)	8.23 (3.73)	9.40 (4.26)	11.47 (5.20)
SKIRT PRESSURE	PSI (NEWTON/M^2)	0.0030 (20.7)	0.0041 (28.3)	0.0057 (39.3)	0.0091 (62.7)
CUSHION PRESSURE	PSI (NEWTON/M^2)	0.0028 (19.3)	0.0037 (25.5)	0.0061 (42.1)	0.0097 (66.9)

* BASED ON SCALE RATIO OF 37.5

** ALL VALUES STANDARD DEVIATION EXCEPT DRAG

TABLE 9

SUMMARY OF MODEL RESPONSES IN SEA STATE 6* AT A WEIGHT OF 125.5 POUNDS (56.93 KILOGRAMS) FOR VARIOUS MODEL SPEEDS

FANS : 3,4,5,8,9 RPM = 20,250

	UNITS	SPEED IN KNOTS	
		6	10
WAVE AMPLITUDE	INCHES (CM)	1.15 (2.93)	1.39 (3.54)
HEAVE	INCHES (CM)	1.07 (2.71)	1.16 (2.95)
PITCH	DEGREES	1.27	1.09
BOW ACCELERATION	G'S	0.313	0.450
C.G. ACCELERATION	G'S	0.139	0.228
STERN ACCELERATION	G'S	0.181	0.219
MEAN DRAG**	POUNDS (KILOGRAMS)	11.16 (5.06)	12.18 (5.52)
SKIRT PRESSURE	PSI (NEWTON/M^2)	0.0063 (43.4)	0.0116 (80.0)
CUSHION PRESSURE	PSI (NEWTON/M^2)	0.0079 (54.5)	0.0125 (86.2)

* BASED ON SCALE RATIO OF 37.5

** ALL VALUES STANDARD DEVIATION EXCEPT DRAG

TABLE 10

IMPACT PRESSURE MEASURED AT A POINT 63 PERCENT
OF CUSHION LENGTH FORWARD OF TRANSOM

RUN NUMBER	LARGEST IMPACT		SECOND LARGEST IMPACT	
	PSI	$(NEWTON/M^2) \times 10^{-3}$	PSI	$(NEWTON/M^2) \times 10^{-3}$
34	1.10	7.58	0.86	5.93
35	1.06	7.31	0.94	6.48
36	0.52	3.59	0.43	2.96
37	1.16	8.00	1.04	7.17
38	1.27	8.76	1.22	8.41
39	1.01	6.96	0.85	5.86
40	1.09	7.52	1.01	6.96
41	0.79	5.45	0.72	4.96
42	1.57	10.82	0.72	4.96
45	0.72	4.96	0.68	4.69
46	0.96	6.62	0.43	2.96
50	0.91	6.27	0.56	3.86
119	1.54	10.62	0.91	6.27
120	1.30	8.96	0.53	3.65

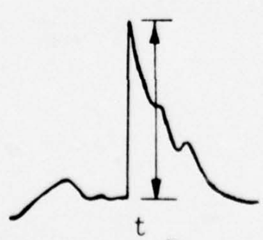


TABLE 11

COMPARISON OF SIGNIFICANT MOTIONS
FOR ANVCE AND AALC CONFIGURATIONS

	7.6 IN.(19.30 CM.) DEEP SKIRT			3.8 IN.(9.65 CM.) DEEP SKIRT		
	MODEL WEIGHT = 125.5 LBS = 56.93 KGS			MODEL WEIGHT = 82.3 LBS = 37.33 KGS		
MODEL SPEED (KNOTS)	SIG. PITCH / SIG. WAVE HT.		SIG. HEAVE / SIG. WAVE HT.	SIG. PITCH / SIG. WAVE HT.		SIG. HEAVE / SIG. WAVE HT.
	DEG/IN	DEG/CM		DEG/IN	DEG/CM	
5.0				2.90	1.14	0.88
6.0	1.06	0.42	0.95			
7.5				2.80	1.10	1.00
14.0	0.65	0.26	0.97			
18.0	0.46	0.18	0.73			

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